GIENE of THE EYE

Dr. COHN

THE

HYGIENE OF THE EYE

IN SCHOOLS.

BY

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"Progressive short sight is in every case ominous of evil for the future."—DONDERS

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PREFACE.

IN the following work will be found, rewritten and extended, an Essay on "School-children's Eyes," which I published in September, 1882, in *Eulenberg's Technical Encyclopædia of Universal Medicine.*

Soon after the appearance of that essay in a great collective work intended only for medical men, a desire was expressed by several publishers, and to myself personally by the Government in Breslau, that I should publish the article separately for the benefit of non-medical circles.

There were, however, a number of reasons which, in my opinion, seemed to make the publication of a mere reprint undesirable. In the first place, the form necessary for the medical Encyclopædia was, I thought, scarcely adapted for a larger circle of readers and, that being the case, it was necessary to have regard to theoretical treatises which had appeared since the publication of the article and also to the very important reports of the Commissions on School Hygiene appointed quite recently. Moreover, it seemed desirable to add a chapter on desks. Lastly, I thought it requisite to preface the work, for the benefit of those readers who do not belong to the medical profession, with a short anatomical, physiological and pathological introduction (Chapters I.—VII.), in which I have included nothing but what is, in my opinion, absolutely necessary for the comprehension of the chapters on Hygiene proper. It is not, however, impossible that even among my medical colleagues one or two may be found to whom this short introduction will not be wholly unwelcome, as serving to refresh their memory of the subjects concerned.

The manuscript was sent to Vienna on the 3rd of January last, but circumstances delayed until now its completion in a printed form distinguished by a type unusually large. New publications which have appeared during the printing have been taken account of, as far as possible, by means of inserted paragraphs and in notes, as well as in the Catalogue of Literature.

I now offer this book to the public, in the hope that it will meet with a kindly reception and indulgent criticism.

However much I have endeavoured to collect together in completeness the whole material, and at the same time to do full justice to every proposal for the improvement of prevailing arrangements in our

schools, yet, considering the keen emulation aroused in this very quarter among all civilized nations of our time, it is only too possible that some details have escaped me and that some have been differently judged of by other observers. I shall be most grateful for any communication on these points, as also for any hint suggested by practical experience.

May the present work contribute towards putting an end at last to the hygienic defects existing in many of our schools and so towards lessening for our scholars, as far as lies in our power, the grave dangers of the short sight which is gaining ground in a manner really terrible.

THE AUTHOR.

Breslau, 24th April, 1883.

ENGLISH EDITOR'S PREFACE.

THE great importance of the subject and the great reputation of the author, Professor Hermann Cohn of Breslau, are, it is hoped, sufficient reasons for publishing this book in an English form.

For the English edition Dr. Cohn has kindly furnished two considerable supplements, on the day lighting and on the artificial lighting of classrooms. Translations of these supplements are appended to the chapters on their respective subjects.

Dr. Cohn has recently constructed, on Snellen's principles, a diagram for testing acuity of vision. It consists of 36 **E**'s arranged in a square. The **E**'s are in different attitudes, that is, they are open at the top, bottom, right or left. The person whose sight is to be tested is required to read these 36 **E**'s, that is, to say in which direction each **E** is open. Learning by heart is hindered not only by varying the order of reading but by the simple contrivance of attaching a separate suspender to each of the four sides of the card on which the diagram is printed.

It will be seen that Dr. Cohn attaches great importance to straight-holders. In a recent publication (on the necessity for school doctors) he mentions a new rest, by Landsberg of Hanover, as possibly more comfortable than Kallmann's.

For much kind assistance the English Editor's best thanks are due to Mr. A. E. Chesshire, Ophthalmic Surgeon, Wolverhampton.

W. P. T.

August, 1886.

EYESIGHT IN SCHOOLS.

INTRODUCTION.

"It is hardly possible for those who are in the possession of strong, healthy sight to estimate at its full worth the part which the eye plays in the development of the mental powers, in forming our views of the world around us and in the relationships which exist between man and man. Orators have praised the eye, poets have sung of it; but its full worth lies hidden away in the silent yearning of those who have once possessed, and now have lost, its light."

Can a treatise like the present find a more beautiful and fitting justification for its appearance than the preceding words, spoken by one called away too soon from among us, the late Albrecht von Gräfe?

The silent yearning of those who have once possessed, and now have lost, their eyesight! It is not the man blind from his birth that suffers the hardest fate; for his need private charity and public institutions have sufficiently provided. But who may find support and suitable occupation for the man whose power of vision is *gradually* failing him? The weight of this misfortune falls heaviest on the student or man of letters. What is left for a teacher, a lawyer, a doctor, a professor, a statesman or any other professional man, when he is attacked in the prime of life with blindness of one eye, while the other is surely drifting through progressive short-sightedness towards

the same fate? And such cases come only too often under the notice of every oculist. When a father brings me his son, suffering from short sight, with the question "What profession do you advise for him?" I can give him the choice of being a gardener, a farmer, a brewer, a baker, or a rope maker, and I can then hope that his calling will at least not aggravate the existing malady. But what is an oculist to say to a man, who after a long and expensive course of study has gained an appointment or a position which will compel him to read and write all day long, and whose one eye is already ruined by hæmorrhage or detachment of the retina, while the other is suffering all the effects of advanced and yearly increasing short sight? Even if a retiring pension is possible, it is almost always accompanied by financial loss; and it would be well for every student, before his matriculation to consult an oculist as to whether his eyesight will be equal to the demand made upon it by his future professional duties.

It is, however, the school itself, as will be shown in the following pages, that must incur the reproach of contributing together with other factors, to the ruin of many an eyesight. How can this be? Partly no doubt from the fact, that neither the teachers of our elementary schools, nor the professors of our universities are instructed or examined in the laws and treatment of the eyesight; and governesses whose certificates testify to their high abilities in other respects have seldom any idea of the factors which are of importance in determining the position in which a child should sit.

Now as teachers are entrusted with the care of not only the mental but also the physical health of their scholars, and that for very many hours in every year, parents have surely a right to demand that their children, who are compelled by law to attend school, should not suffer injury to their health by that attendance.

At the present moment, indeed, there are many Principals of schools who re-echo the complaints made by medical men for the last ten years, and who feel an interest in school-hygiene, but it is not so long ago that Head Masters of high attainments as philologists were too much absorbed in their Horace and their Sophocles to be conscious of the existence of a whole literature on the very important question of school desks or, if conscious, to do more than regard the matter with lofty indifference. It was left, therefore, for doctors to urge on this movement, men who were guided both by scientific instinct and by just and practical aims; and they were never weary of popularising in lectures and pamphlets those things which they knew to be true.

The most distinguished oculists of earlier times had already perceived the necessity of some instruction respecting the treatment of the eye; and so far back as the year 1800 G. J. Beer, a Viennese professor, published an excellent work entitled "Treatment of healthy and of weak Eyes," which contained many important hints for teachers. In 1865 there appeared in Prague the third edition of the "Treatment of the Eyes in a healthy and in a diseased condition," a first-class book by Professor von Arlt. Lectures upon the Eye were given by Helmholtz and by Albrecht von Gräfe. A great number of smaller writings have been published on the same subject in every language. In 1877 a capital Manual of Hygiene for the School by Baginsky was brought out in Berlin. And yet it is in our schools that we meet every day with the grossest violations of the first laws of hygiene concerning the eye.

These are the reasons which seem to promise some degree of usefulness to a new work, treating briefly the Hygiene of the Eye in our Schools. All doubtful and controverted points which find their place in the special text

books of anatomy, physiology and medicine have been as far as possible avoided, and only those are introduced which are unquestioned or require further comment and explanation.

For without some knowledge of the most important anatomical and physiological facts of the case it is impossible to understand the Hygiene of the eye; and I therefore preface this work with a few anatomical and physiological remarks. These, however, have reference only to those parts and processes which are of obvious importance to the subject.

CHAPTER FIRST.

Prefatory Anatomical Remarks.

The Eye,* as is well known, is about an inch in diameter and spherical in shape. It is composed of clear fluid, and of thin membranous tissues in part boxed into each other like the scales of a bulb, which explains why the eyeball is also called *bulbus.*

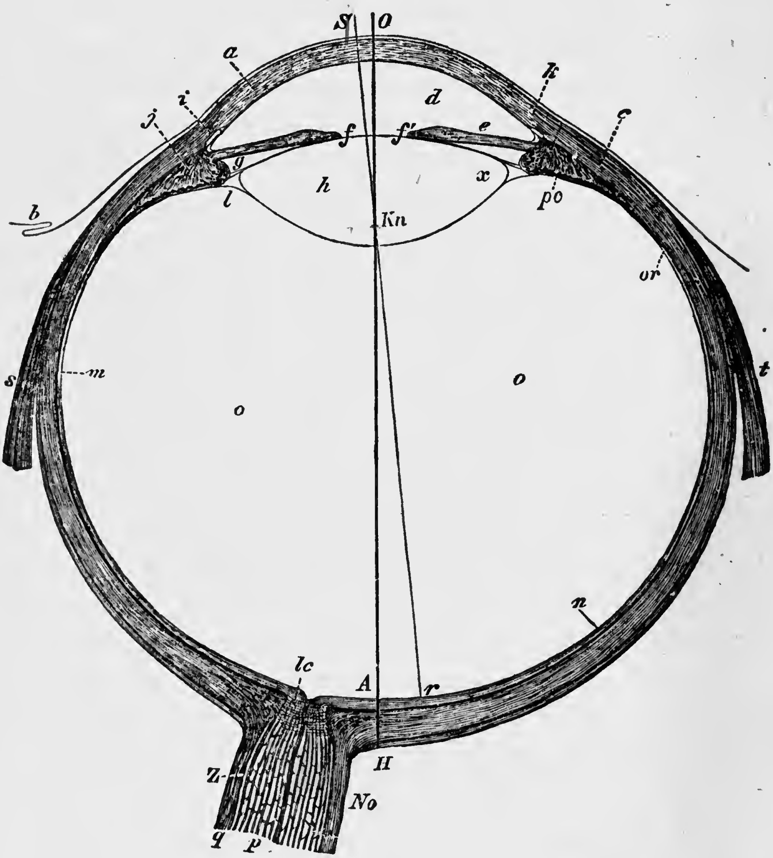
The outer case, of which only the front part is generally visible, is called the *sclera* (Fig. I., *c.*). It is of a blueish white colour, like porcelain, but in old age turns a yellowish white. The back part of the *sclera* lies in the fatty tissue of the socket *(orbita)*, which also encloses the optic nerve. The *sclera* (from *scleros*, "hard") is the strongest and thickest of the three layers of skin *(sclera, choroid*, and *retina)*, for it is the case which holds the eye itself. It is also called in German *lederhaut* ("leather skin").

This case of the eye is not closed in front, but is covered by the transparent *cornea*, which fits into it like the glass into the case of a watch *(a)*. The cornea is generally as transparent as the purest water and as smooth as the finest mirror. Like every convex mirror, it presents upright and diminished images of all the objects it reflects; and that is why we see a miniature reflection of our own face in other people's eyes. The cornea measures from 10 to 12 millimeters across the base and is rather more than 1 millimeter thick.

* For the demonstration of this subject no school should be without a good model of the eye, in glass or papier maché, 10 times the natural size.

If we imagine the eyeball as representing the terrestrial globe turned through 90 degrees, the front of the cornea (*O*) will be the front pole, and the furthest back point of the sclera (*H*) the back pole, and the straight line which unites these two points is called the *axis* of the eye. The *equator* of the eye runs around it, just where we should place a knife to divide the eyeball into halves horizontally, and the *meridians* connect of course the front with the back pole.

Fig. I.



Behind the cornea is a space called the *anterior* chamber, filled with a clear colourless liquid, the "aqueous humour," which can be drawn off by puncturing the cornea. This space or chamber is only from 2 to 3

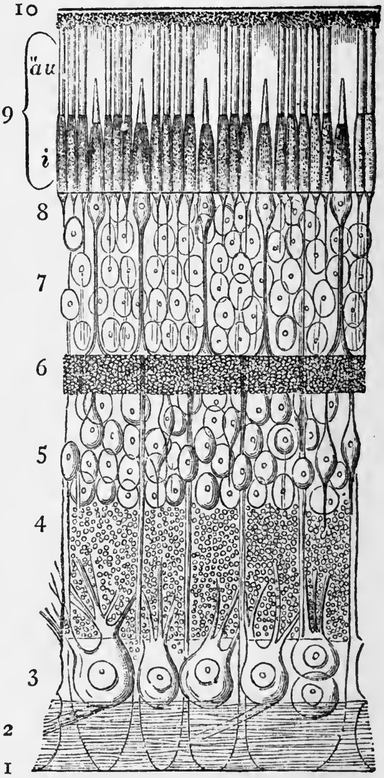
millimeters in depth. At the back of the chamber lies the *iris (e)*, which is to the cornea what the dial-face of a watch is to the glass. It is a ring-shaped, vascular membrane, formed like a frame, at right angles to the axis of the eye and having in the centre a hole or opening called the *pupil (f f')*.

The colour of the iris is different in different eyes; for it is not the eye itself, but only the iris that is blue, brown or grey. The iris of every new-born child is blue, but grows darker-coloured in many cases within the first few days. There is no such thing as a black iris; even in negroes and Nubians it is only dark brown. Light blue is the prevailing colour of the iris in Germany; out of 760,000 scholars in Bavaria, two-thirds were found to have eyes of a light colour. The colouring matter is stored for the most part behind the iris, but there is no *blue* colouring matter in the iris itself; the iris only appears to be blue through interference, if a dull or colourless front layer of it occurs in front of the dark hinder layer, just as a dark mountain range looks blue when seen through a dense and misty stratum of air. But if the front parts of the iris contain any colouring matter, then the eye appears brown or grey or exhibits any conceivable intermediate shade of colour.

In the centre or, to speak more strictly, a little lower down and nearer to the nose, the iris is, as it were, perforated by the *pupil*, which looks black, just as the opening of an underground cellar looks black when seen from the street. This opening is capable of being dilated and contracted, but not by any effort of its possessor. In the dark and in looking a long way off, the pupil expands of itself, while in a bright light and in looking at objects near at hand, it contracts. These two movements are effected by two muscles situated in the iris, the annular *Sphincter Iridis* which contracts it, and the star-shaped *Dilatator Iridis* which expands. The

diameter of the pupil varies in the generality of cases between 4 and 5 millimeters. There is, however, a drug by means of which it can be expanded in ten minutes to 9 millimeters; while another drug has the property of contracting it to the width of 1 millimeter. The dilatation is effected by *Atropine*, which is obtained from the *Atropa Belladonna* or Deadly Nightshade, and the contraction by *Eserin*, which is extracted from the poisonous African plant *Physostigma venenosum* or Calabar Bean.

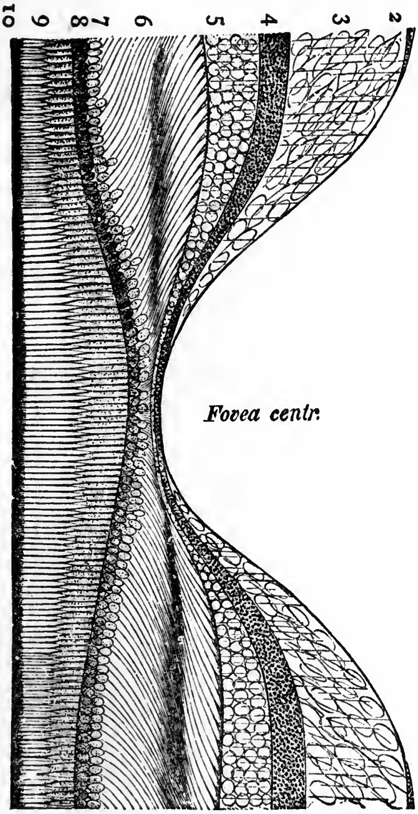
FIG. II.



The inner surface of the *sclera* is covered by the choroid membrane or *chorioidea* (*m*). This contains a great number of small veins supplying blood to the eye; it abounds also in a dark-coloured pigment and, like the sclera, has a central opening which is filled up in front by the iris. Immediately behind the iris it swells to a thick band, 6 millimeters broad, forming what is called the *ciliary body*. The latter consists of two parts: the muscle, known as the ciliary or accommodation muscle (*i*) (tensor chorioideæ), and an uneven, more corrugated surface, facing the centre of the eye, and called the *ciliary processes* (*processus ciliares*) (*pc*). We shall treat of these important parts of the eye in greater detail further on.

Supposing an eye cut through along the line we called the equator, the front half, when looked

FIG. III.



at from behind, would shew us the ciliary processes lying mostly towards the centre, and forming a circle of 70—72 folds.

The third membrane, concentric with the sclera and the choroid, is the *retina* (*n*). In a living condition it is almost transparent, but after death it is of a dull, whitish colour. It extends towards the front of the eye as far as the beginning of the ciliary body (*or*), and ends there in a serrated margin the (*ora serrata*). The retina is thickest near the entrance of the optic nerve (0·22 mm.) and decreases in thickness towards the circumference, being only 0·09 mm. thick at the *ora serrata*.

The clear, white entrance of the optic nerve is seen, not at the pole (*H*) but rather nearer the nose (*no*) ; and the yellow spot (*punctum aureum* or *macula lutea*), the spot with which we see most clearly, is found at the place marked (*r*), 3 mm. nearer the temple, and rather lower down than the optic nerve. This yellow spot (Fig. V.) is elliptical in form and lies horizontally ; it has in the centre a highly transparent and very deep depression called the *fovea centralis*.

The structure of the retina is extremely complex and, when examined with the aid of a microscope, discloses in section ten layers which are represented in Fig. II.

(taken from the admirable researches of Max Schultze). These layers, reckoning from the centre outwards toward the choroid, are named as follows: 1.—The inner limiting membrane. 2.—Nerve-fibres or optic nerve. 3.—Layer of ganglionic cells. 4.—Inner granular layer. 5.—Inner granular layer, larger size. 6.—Outer granular layer. 7.—Outer granular layer, larger size. 8.—Outer limiting membrane. 9.—Layer of rods and cones. 10.—The *epithelium* or *hyaloid membrane.*

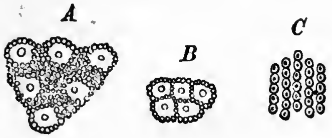
The most important of these ten layers, as far as our sight is concerned, are the 2nd, 3rd, 9th and 10th.

The second layer is that of nerve-fibres. When the optic nerve has passed through the opening of the sclera and the choroid (Fig. I. *lc.*), the nerve-fibres of which it is composed expand in every direction over the whole retina as extremely delicate transparent fibrils 0·0005 to 0·0045 mm. in diameter. They surround the *macula lutea* and are connected with the third layer of large ganglionic cells. These ganglionic cells possess a cellular nucleus and from two to six extended fibres. They are found in the greatest numbers at the *macula lutea,* where they overlie each other eight or ten deep (Fig. III. 3). Towards the circumference the stratum of ganglionic cells gradually decreases in thickness.

The ninth layer is that of rods and cones. This layer is called by Kühne the layer of optic cells. The rods (Fig. II. 9) are long cylindrical figures, between which lie the cones; the latter are shaped somewhat like a bottle, the neck looking towards the choroid and the larger part towards the interior of the eye. Both the rods and the cones have an inner (*i*) and an outer part (*äu*). The outer part is brilliant and streaked across; the inner part is granulated and less brilliant. The rods are only 0·0018 mm. in breadth, while the cones are rather thicker, 0·004 mm. The cone has at its termination a still slenderer rod, the cone-rod, which measures only 0·001 mm. in diameter.

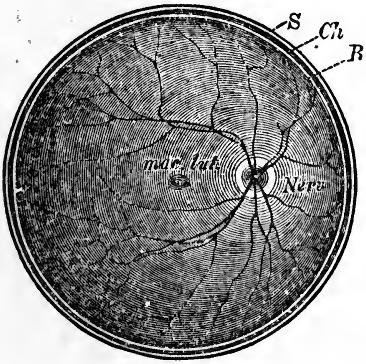
The surface of the optic cells resembles a beautiful piece of mosaic; but the rods and cones are not evenly distributed over the retina. Cones alone are found at the yellow spot, where they are clearly visible like large circles (Fig. IV., *C*); while towards the circumference each cone is surrounded by a circle of the smaller rods (Fig. IV., *B* and *A*), and on the margin of the retina, the cones disappear altogether, to make room for the rods.

FIG. IV.



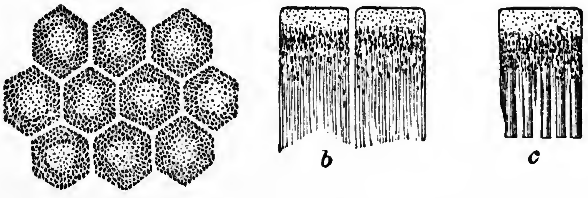
The connection of these 10 layers one with another is not yet quite clear, as the microscopic examination of this part of the eye is extremely difficult; but it may safely be taken for granted that the nerve-fibres which enter the retina through the optic nerves are connected with the gangli-onic cells, and through them and the various granulated layers with the rods and cones, the latter being the true light-receptacles and real nerves of sight.

FIG. V.



Behind the rods and cones is the 10th layer, which consists simply of hexagonal cells containing a dark brown

FIG. VI.



pigment, known as *Fuscin.* The surface of these cells is also like a delicate mosaic, and in examining them in

profile it is seen that they send out to the rods and cones a large number of fine connecting threads resembling eyelashes (Fig. VI., *b* and *c*).

The *macula lutea* (Fig. III.) is distinguished by the great number of ganglionic cells and of cones, the latter being found elongated and pressed closely together in the *fovea centralis* or central depression of the yellow spot. The space between the iris and the retina is filled by the crystalline lens and the vitreous body. The former (Fig. I., *h*) is enclosed in a very thin transparent case or capsule, bi-convex in form, the front surface being more slightly curved than the back. It is perfectly transparent, with great power of refraction, strong, and at the same time soft and elastic. The margin of the lens (Fig. I., *x*), called the equator, is laminated; it possesses a skin and a nucleus, and can to some extent alter its shape. In old age it becomes harder and yellower. The dimness of the lens which occurs sometimes in later life is called cataract, and is a sign of advancing years like the whitening of the hair; the pupil looks grey instead of black, and the patient cannot see, because the dulled lens cannot admit a sufficient amount of light to the retina.

It is of the greatest importance to the right understanding of the hygiene of the eye, that the manner in which the lens is securely fixed should be clearly understood. The lens lies behind the iris and is fastened to the ciliary body by a singular band called the *Ligamentum suspensorium lentis* or *Zonula Zinnii* (Fig. X., *Z*). A horizontal section will shew us that there exists a triangular space *q* between the equator of the lens *x* and the ciliary processes *n*. This space is called Petit's canal and is bounded by a delicate membranous lamella at the *Z* and *p*; *Z* being attached to the front, and *p* to the back of the capsule of the lens. These two delicate membranes join together at the

ciliary processes (n), and are probably connected with the hyaloid or vitreous membrane which surrounds the vitreous bodies: Z is accordingly the front plate, and p the back plate, of the zonule of Zinn, or ligament which suspends the lens; and these plates fasten the capsule of the lens to the ciliary processes.

The space between the iris and the lens (between T and Z in Fig. X.) is, in life, capillary and extremely narrow, and is called the *posterior chamber;* and behind the lens lies the vitreous body (Fig. I., o) or *corpus vitreum*, which keeps the sclera, choroid, and retina distended and fills up the greater part of the eye. It is gelatinous, perfectly transparent and surrounded by a delicate membrane—called the vitreous or hyaloid membrane. The optic nerve enters the eye through an opening in the sclera and choroid, rather nearer the nose than is the axis of the eye. (Fig. I. *No.*) It is enclosed in a strong outer sheath q and a more delicate inner one Z, between which a very small dividing canal enters for some distance into the sclera. The outer sheath v, and the canal *ca* will be seen still more clearly in Fig. XXIII. The optic nerve is made up of a great number of nerve-fibres passing through a reticulated or sieve-like substance called the *lamina cribrosa* (*lc* in Figs. I. and XXIII.) in which they lose their shining outer surfaces, and shewing themselves as fine transparent cylinders in the sheath or *papilla optica*, whence they radiate in all directions, as the delicate second layer of the retina, being found, however, more freely distributed towards the inner than the outer side. Inside the optic nerve we find the *Arteria* and *Vena centralis retinae*, whose ramifications can be traced with the ophthalmoscope from the spot where the nerve enters the eye to the remotest parts of the retina (Fig. V.). The optic nerves themselves are insensible of light, in fact blind; they merely guide the impression of light to the brain, where they cross and recross each other.

In addition to the parts of the eyeball just described, the eye has a number of auxiliary apparatuses which, as they are but remotely connected with the hygiene of the eye in our schools, need find only a passing mention. The eye can move without altering its place; it is simply turned, in any direction, upon its pivot, which is situated at about the centre of the eyeball. This movement is effected by six voluntary muscles. The four straight muscles of the eye, or *recti*, originate at the back of the eye near the point of the socket and have their thin broad fibres inserted in the sclera towards the front (Fig. I. *s*, *t*), the upper, lower, and inner recti at about 5 mm. from the corresponding margin of the cornea, the *rectus externus* at nearly 7 mm. from the outer margin of the cornea. There are also two diagonal muscles, or *obliqui*, which, however, do not concern us here. These six muscles hold the eye in equilibrium, and by the gradual successive contraction of one or more of them the eye can be placed in any position desired. In looking at objects close to us, the inner straight muscles (*recti interni*) of the two eyes are moved simultaneously.

The eyelid has a thin lining called the *Tarsus*, between which and the outer skin lie fine muscular fibres which extend in a circular direction from the inner muscle of the eye to the outer, forming the muscle by means of which we close the eye, and which is called the *sphincter palpebrarum* or *orbicularis*.

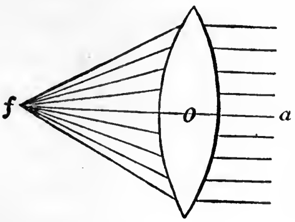
Lastly, we must mention the connecting membrane or *conjunctiva*, so called because it connects the eyelid with the eyeball. It is a very thin, almost transparent mucous membrane, by the aid of which the lid more easily rises and falls over the eyeball. It lines the eyelid internally and forms a reflecting fold from the lid to the eyeball, which it keeps moist, and with the exception of the cornea, covers.

CHAPTER SECOND.

PHYSICAL AND CHEMICAL PROCESSES OF SIGHT.

In order to understand clearly the physical processes of sight, a few remarks on the *Camera Obscura* will be necessary as a preface. The Camera was invented in the year 1560 by John Baptist Porta and is familiar to every one now as the photographic camera, a dark chamber into which the light falls only from the front. The light there received passes through a bi-convex lens of glass; that is, a lens bounded on each side by a portion of a spherical surface, a lens of the same shape indeed as the spectacles worn by old people for reading.

FIG. VII.

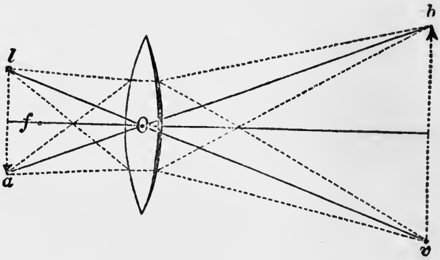


Rays of light which come from a great distance, from the sun for instance, and which therefore fall on the lens in parallel lines, are gathered up by the lens into a point called the focus (Fig. VII., *f*), where the sun-picture is in a measure photographed. It has been well remarked by Helmholtz that it is not generally taken into account that the lens itself casts a shadow, like an opaque body, though it is made of transparent glass. The light is therefore gathered up by the refraction of the glass lens, and directed to the bright sun-picture, so that both light and heat are much more intense there than in the unrefracted rays of the sun (Lectures on Popular Science, II, p. 14).

But when the sun's rays reach the lens, not from an infinite distance, but from luminous objects at a *finite*

distance, they form beyond the glass a miniature picture in inverted position, which can be captured in the air. In Fig. VIII. *la* is the inverted picture of *bv*. If we hold a photographic lens at a certain distance from a sheet of paper held opposite a window, we can easily throw upon the paper a small, inverted picture of the window. The picture is best seen, when no light falls upon it from the sides, and that is why the sides of the photographic chamber are closed so as to exclude all side-lights and to allow the inverted picture thrown from the lens to be exactly caught on the ground glass at the back of the camera.

FIG. VIII.



The place at which the picture appears depends altogether upon the degree of convexity of the lens; for the more convex the lens is, the nearer to it will be the place of the picture; and the flatter the lens, the farther from it will be the picture. In the former case the lens is said to have a short focal distance or a strong power of refraction, and in the latter, to have a great focal distance or a weak power of refraction.

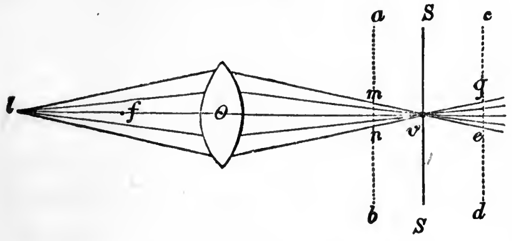
Some years ago boxes of glasses or of spectacles were used, containing a succession of convex lenses, the focal distances being measured by inches and indicated by fractions of which 1 was the numerator, while the denominators expressed the focal distances in inches. Thus a glass marked $^1/_2$ meant a glass of which the focal distance measured two inches; $^1/_4$, a glass of which the focal distance measured four inches; $^1/_{10}$, a glass of which the focal distance measured 10 inches, and so on.

More recently, however, measurement by meter has come into use even for spectacles, and has introduced the idea of Dioptrics. The dioptric unit is the refracting

power of a lens, whose focal distance is 1 meter. Spectacles are now numbered, not in fractions inversely proportional to focal distances, but in whole numbers directly proportional to powers of refraction. Such glasses are called metric or dioptric lenses; thus No. 1 dioptric lens (No. 1 *D*) is a lens of such refracting power that its focal distance is 1 meter. If a second lens of the same power is placed over it, we obtain a lens, No. 2 *D*, of which the focal length is of course half a meter. A lens No. 10 *D* has a focal length of 10 centimeters or one-tenth of a meter, and so on. According to the old style of measurement No. $^1/_2$ is the strongest, and No. $^1/_{120}$ the weakest lens. In dioptric lenses No. 0·25 *D* is the weakest and No. 20 *D* the strongest.

The stronger the refracting power of the lens in the camera, the nearer of course must be the screen or plate which is to receive the picture: therefore with a lens No. 10 *D* the plate must be 10 centimeters distant; but with + 5 *D* (+ means convex) it must be $^1/_5$ of a meter or 20 centimeters distant. The chamber must therefore be shorter from front to back, the stronger the refracting power of the lens at its entrance. It need hardly be said that we are presupposing a perfectly clear, bright lens, if the picture on the plate is not to be blurred and indistinct.

Fig. IX.



But the clearest lens will not prevent the picture from being indistinct, if the plate is further from the lens than the refracting power of the glass demands. If the screen *S S* (Fig. IX.), which received at *v* a clear sharp picture of the point *l*, were moved forward to *a*—*b*, the picture at *v* would be indistinct, and the same effect would

follow if the screen were put back to *c—d*. For the rays of light, although gathered near to each other, form on the plate moved forward to *a—b*, a circle, an indistinct circle, a so-called *circle of dispersion*, of which the diameter is *m—n*; and if the plate is moved back again to *c—d*, the rays of light, which are now divergiug from *v*, form again upon the screen a circle of dispersion of which the diameter is *g—e*; for rays always diverge from a luminous point into which they have been gathered, and therefore in the present instance they diverge from *v*. It follows that a distinct picture is only possible when the screen is at the exact distance from the lens required by the refracting power of the latter.

We must, indeed, modify the above remarks when the rays diverge from a point extremely near the lens: the picture in that case, from causes which it is not necessary to explain here, will fall somewhat further *beyond* the focal distance of the lens, and the plate of the camera will have to be drawn back so as to be further from the front.

The process of photography corresponds very closely to the process by which a picture is formed in the eye: for the eye, too, is a *camera obscura*, enclosed in a round instead of a square case. For, as we said in the last chapter, the choroid membrane abundantly contains a dark pigment. This corresponds to the black lining of the photographer's camera; and the eyeball, although not hollow like the camera, is filled with transparent fluids, while instead of the single photographic lens we have in the eye several refracting media, namely, the convex, transparent cornea, of which the curve and position cannot be altered, the aqueous humour, and the crystalline lens itself.

When the rays have passed through these three transparent media, they do not enter into air, but into the vitreous body which refracts them more strongly than air

can do; so that, having more highly refracting parts, the eye has of course a much higher refracting power than the photographic apparatus; accordingly upon the retina at the back of an eye, only 1 inch in depth, a clear image is produced. We see now why the cornea, aqueous humour, crystalline lens and vitreous body are termed the *refracting media* or *dioptric apparatus.*

The work of the sensitive plate of the photographer is done in the eye by the retina and its optic cells. The clearest picture is obtained at the yellow spot at the end of the axis of the eye. Kepler was the first to show on optical grounds that a diminished, inverted image must be formed upon the retina; and so early as the year 1619 the famous Father Joseph Scheiner demonstrated at Rome this little picture traced at the back of a human eye. In spite of these authorities it was thought by many, even as recently as our own century, that the *choroid* was the membrane on which the picture was obtained; but it is now positively established that it is traced nowhere else but in the rod-and-cone stratum of the retina.

Lastly, we find in the photographic camera the *diaphragm,* an important apparatus in the formation of the picture. The rays which pass through the edge of a lens are refracted much more strongly and irregularly than those which pass through the centre. In order therefore to obtain as clear a picture as possible upon the sensitive plate, the side-rays which enter the camera obscura (as in any other optical instrument) are intercepted by diaphragms. This work is done in the eye by the *iris,* which prevents the rays of light from passing through the edge of the lens. The iris regulates also the *amount* of light, contracting the pupil in a bright light so as to allow a smaller number of rays to strike the sensitive retina, and expanding in a dim light so as to admit as many rays as possible.

The process by which the picture is produced in the eye is not the only one which resembles photography, as we shall admit when we turn to the chemistry of vision. The photographer moistens his plate with iodide of silver; all light parts of the object decompose the iodide and leave on the corresponding place a dark picture, while dark objects do not decompose the iodide. In this way the photographer obtains a negative from which he afterwards prints off a positive.

Now in the year 1876 Ball made the significant discovery that the retina of living animals was of a reddish purple colour, which became pale at the expiration of scarcely a minute; and further, that the colour which disappeared from the retina of frogs dazzled by a strong light came back in the dark.

Upon this, Kühne proved that light was the sole reason of this loss of colour, and that the colouring matter or *Rhodopsin* was contained in the rods, the cones being entirely destitute of it. He was able by means of gall to extract the *rhodopsin* from the rods and to study its photo-chemical properties outside the body of the animal. In the living eye the rhodopsin can of course be driven out only by strong light, and Kühne succeeded in taking real *optograms* (impressions akin to photographs) on the retina of animals. The animals were previously kept in the dark for a long time to favour the accumulation of a large quantity of colouring matter; they were then held for a moment in front of a window upon which some strips of dark paper had been pasted, and their heads were immediately cut off. The retina was then found to have traced upon it, in a red colour, only those parts of the window upon which the dark paper had been fastened, while in every other part it was colourless from the effect of the light.

The restoration of the colouring matter is effected by the epithelial cells of the 10th layer of the retina. The

chemical changes of the optic cells produce, most probably, further chemical changes in the ganglionic cells and nerve-fibres which lie in front of them; the latter pass through the optic nerve into the brain, where alone, and not in the eye itself, is the home of sight.

CHAPTER THE THIRD.

Accommodation.

Photography has at its command three methods by which it can obtain pictures of objects near at hand. The first of these is the drawing out of the ground glass, on which the picture is taken, further back from the front lens. If the eye could imitate this method, it would be by moving the retina further back when we look at near objects. But the eye has no power to do this.

The second method employed by photographers for the same purpose leaves the ground glass unmoved, but alters the position of the front lens, moving the lens forward by means of a screw, and so increasing the distance between it and the ground glass; for, the nearer the object, the further the lens must be pulled out, and the further off the object, the more the lens must be screwed back. If we had such a method of thrusting forward the crystalline lens of the eye we should be able by employing it to obtain pictures of near objects on the retina. But this power also is denied to the eye.

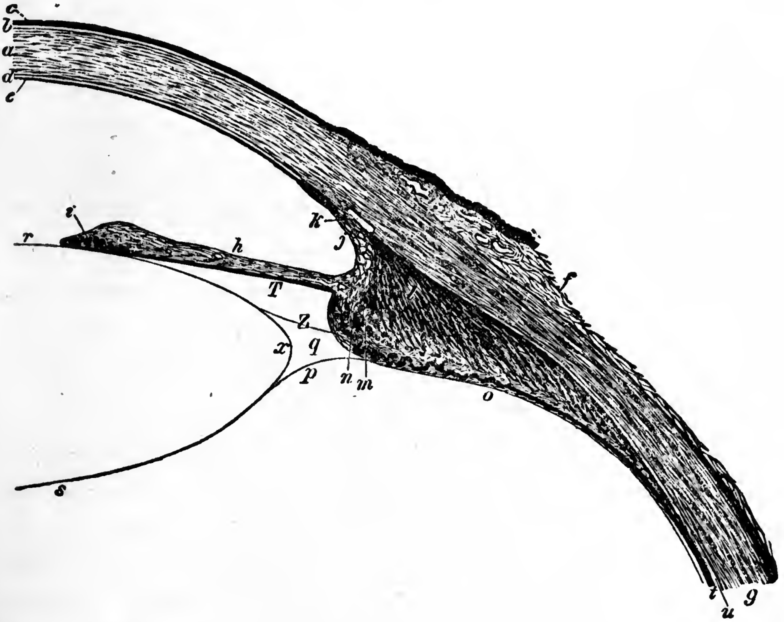
Lastly, the photographer has a third method of obtaining the impression of near objects upon the plate, without either drawing out the plate further back, or moving the lens further forward. He has only to place before the lens, while leaving both it and the plate in their original position, a second, third, and fourth lens, indeed as many additional lenses as are needed by the greater nearness of the object which he intends to photograph. A lens of double power has exactly the same power of refraction as two lenses of equal power placed one before the

other. If, therefore, the eye possesses a mechanism by which it can give to its lens, without displacing it, a greater or less degree of convexity, that is, can, as it were, place before it a second lens, can make its lens thicker, it will be able to see clearly both near and distant objects. And this most important mechanism the eye does actually possess, in what is called *Accommodation.*

The greatest thinkers have mastered a host of difficulties in discovering this arrangement, and it is only in very recent times that its processes have been clearly and perfectly set forth in the works of Sanson, Helmholtz, Brücke, Hensen and Völckers.

The crystalline lens is elastic, and would, if left to itself, assume a much more spherical form than it has in life.

FIG. X.

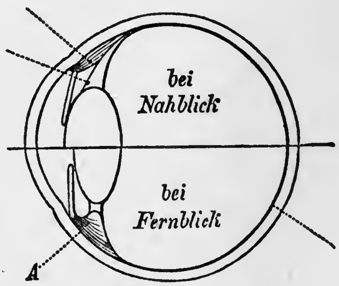


There exists, however, a muscle at the margin of the lens which, by contracting, flattens it permanently, so as to make it throw upon the retina the impression of distant objects. This muscle, which surrounds the lens in radiating folds not unlike a frill, is called the *Zonula*

Zinnii or *Ligatorium suspensorium lentis* (Fig. X., *Z.*) It is attached to the ciliary processes and flattens the lens by expanding it towards the circumference. The tension of the ligament can be diminished by the ciliary or *accommodation* muscle which is found in the ciliary body. This muscle begins behind the margin of the cornea at (*k*) and reaches back to the choroid membrane (*f*); by contracting, it draws the choroid forward, the ciliary processes moving with it in the same direction (*n*), and, since the zonula (*Z*) is attached to the latter, it also is moved forward by the contraction of the ciliary muscle.

The forward movement of the zonula forces the lens in obedience to its elastic properties to assume a thicker and more spherical form instead of the flattened form it has when at rest. The front surface of the lens in particular becomes much more convex, and has in a measure the same effect as that produced by placing a second lens in front of the first without altering the position of the first, and thus of course the lens is made to project on the retina the picture of near objects. The eye is in this manner *accommodated*, or focussed, for near objects. The upper half of Fig. XI. shews us the working of the accommodation muscle for near sight, and in the lower half we see the situation of the various parts when accommodated for far sight.

FIG. XI.



bei Nahblick—"*for near sight.*"
bei Fernblick—"*for far sight.*"

The *radiating* fibres of the accommodation muscle work as we have described; but there are within the same muscle circular muscular fibres lying nearer to the edge of the lens (Fig. X. *m*), which by their contraction relax the zonula still more.

Hensen and *Völckers* have by their recent experiments shewn what *Brücke*, the discoverer of this muscle, had

already suspected, that the choroid is really drawn somewhat forward by the contraction of the accommodation muscle and that in this way the zonula is relaxed. They introduced a needle into the ciliary muscle of a dog somewhere near the place marked *l* in Fig. X. while they passed a second needle through the sclera and choroid (say behind *t* in Fig X.); and while the first needle remained perfectly stationary during the excitation of the accommodation muscle, the free end of the other needle moved quickly *backward*, which would have been quite impossible without a forward movement of the choroid.

Now it is upon this very accommodation muscle that in reading and writing we impose a twofold burden; on the one hand it is made to relax the zonula and by so doing to bring the lens into a more spherical form, and on the other hand it is made to draw the choroid forward. And this twofold work is a main source of injury to the youthful eye, so that it is impossible to lay too much stress upon the right understanding of this mechanism of accommodation.

NOTE.—A little model of the accommodation muscle has been prepared according to my instructions by the optician *Heidrich*, 27, Schweidnitzer Strasse, Breslau.

CHAPTER FOURTH.

Acuity of Vision.

The delicacy of the sense of touch is estimated by the power of distinguishing on the skin two separated points of a pair of compasses, which points a duller sense would only feel as one. At the tip of the tongue they can be distinguished when they are only one millimeter apart; on the end of the finger not until they are 2 mm. apart, on the hand not within 20 mm., on the neck not within 30 mm., and on the upper part of the arm not within 60 mm.

In the same way we estimate fineness of vision, *acuity* of vision, by the power of distinguishing two dots lying near together and seen of course under a good light. The distance at which these dots can be seen as two clearly separate objects will depend upon the distance apart at which their images are traced upon the retina, and that distance will itself depend upon what is called the angle of sight, or in other words the angle formed by two straight lines drawn from the two points to the optic centre of the eye. By the optic centre of the eye is meant the optic centre of the refracting surfaces of which the eye is composed. This point is situated about half a mm. in front of the posterior surface of the lens (Fig. I. *Kn*). All the rays of light which pass through this point are continued unrefracted. If from the ends of an arrow (*AB* Fig. XII.) two straight lines are drawn to the optic centre *k* and are produced, they strike the retina at the points *d* and *c*.

These lines are called lines of direction, and the optic centre is their point of intersection.

FIG. XII.

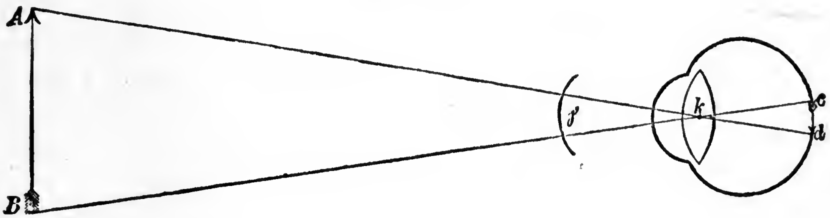
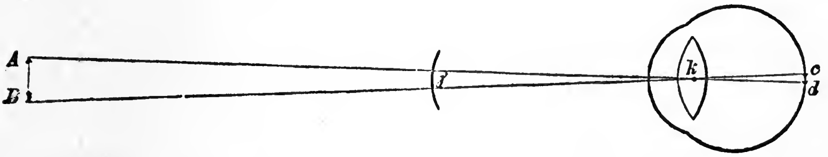


FIG. XIII.



The angle *AkB*, or γ, contained by these two lines is the angle of sight. *AkB* is of course equal to *dkc*.

The further a given object is from the eye, or the smaller the object at a given distance, the smaller will be the angle of sight (Fig XIII.); and it will eventually be so small that the points *A* and *B* can no longer be distinguished upon the retina as separate points. The size of the picture upon the retina can be easily calculated from the angle of sight γ.

If the latter equals 1 minute ($^1/_{60}$ of a degree), the size of the retina picture in the normal eye will be 0·0043 mm. Now each cone-rod is only 0·001 mm. in diameter, so that if $\gamma = 1'$ and the retina picture is accordingly 0·004 mm. wide, the bright points *A* and *B* strike two cone-rods which do not lie close together, and consequently *A* and *B* are distinguished as two separate points.

The angle of sight of 1′ was taken by Prof. Snellen of Utrecht as a standard measure of acuity of vision. He constructed letters and characters such as to be seen at a given distance at an angle of 1 minute. In individual

cases the acuity of vision *(V)* is determined by finding the minimum angle required for the recognition of the letter or character.

No school library should be without a copy of Snellen's Test Types or *Opto-Typi* (published by Peters, Berlin.) These test types are so made that each thickness of a letter and every narrow space left between the separate parts measures $^1/_5$ of the height of the whole letter. If, then, such a letter is seen by the eye at an angle of sight of $^1/_{12}$ degree, or 5′, each separate part of the same letter will be seen at an angle of 1′. Above each line of letters Snellen has printed the number of meters which expresses the distance at which the letters are when the angle of sight is 5′.

Accordingly if we find the figure 6 above a line of the printed letters, we know that they will be seen by the eye at a distance of 6 meters at an angle of sight 5′, and each separate thickness of the letter at an angle of sight 1′. If, then, these letters are read by the eye up to a distance of 6 meters, its acuity of vision $V = {}^6/_6 = 1$; while, if they are read only up to a distance of 3 meters, the acuity of vision $V = {}^3/_6 = {}^1/_2$, and in that case the separate parts of the letters are not distinguished at a less angle of sight than 2′. But if an eye could see the types at a distance of 12 meters, V would be $^{12}/_6$ or 2, and the same eye would see clearly at an angle of $^1/_2$ a minute, in other words would have double acuity of vision. Acuity, then, is generally expressed by a fraction of which the denominator *(D)* indicates the number of meters marked above the letters, which number shews the distance up to which the letters are read by the normal eye, while the numerator *(d)* shews the distance up to which they are actually read by the eye which is being tested. Thus $V = \frac{d}{D}$.

In Fig. XIV. we copy some letters taken from No. 6 of Snellen's Test Types, and any one who is unable to

read them easily at a distance of 20 feet has less than normal visual acuity. The test types have, besides separate letters, whole paragraphs printed in different sizes, and the distances are given at which they are seen at an angle of 5′.

FIG. XIV.

B E P F

L D Z T

F P D L

The shape of the letters is of great importance. Mauthner has very truly observed that the Latin O is much more easily recognised than the spaces in C and G are distinguished from the space in O. Now what we have to aim at is that the letters should not be guessed at but clearly recognised.

For the testing of very young children and of those who are unable to read, Snellen has published types made according to his system and containing, instead of letters, characters somewhat like the following: ⊔ ⊓ ⊏ ⊐. The child has only to be asked whether they are open at the top or at the bottom, on the right side or on the left. Mayerhausen has recently preferred Arabic numerals to the letters contained in Snellen's test types.

The tests most mathematically correct are the point tests constructed by Dr. Burchardt of Berlin and called International Sight Tests; but for use in schools Snellen's test types are, for practical reasons, better fitted.

De Haan, a pupil of Donders, has by the aid of Snellen's types determined *V* for different ages and found that up to the age of thirty *V* generally remains almost unaltered at $^{22}/_{20}$, that at forty years of age the average is $^{20}/_{20}$, at fifty $^{18}/_{20}$, at sixty $^{14}/_{20}$, at seventy $^{12}/_{20}$, and that at eighty it has fallen to $^{10}/_{20}$, or just half the acuity of a healthy normal eye. The reason of this not very consolatory

phenomenon is sought for by De Haan and Donders in the diminished transparency of the lens and of the vitreous humour and partly in some alterations in the retina, the optic nerve and the brain, not as yet understood. But these statements concerning the gradual failure of acuity cannot claim universal authority because they are based upon the examination of too small a number of cases, namely, 281 in Holland.*

As far back as the year 1871 I had pointed out† that the eyes of children living in a mountainous region had when in a healthy condition a much greater acuity of vision than that given by Snellen as normal. At Schreiberhau in the Riesengebirge I examined 244 eyes of the village-school children, and found that only 7 saw the hooked characters of Snellen's test table No. 20 finally at 20 feet; while 38 saw them finally at between 22 and 29 feet, 85 at between 30 and 39 feet, 104 at between 40 and 49 feet, and 10 at the great distance of between 50 and 60 feet. Thus it is quite usual to find among young people eyes possessing twice the keenness of sight given by Snellen as normal; even treble acuity was found. I obtained a similar result with Dr. Burchardt's point tests.

Burchardt made the same experiments with the eyes of soldiers, and found that out of 474 eyes only 61 had $V < 1$, while 43 had $V = 1$, 281 had $V > 1$ and < 2, 73 had $V = 2$, 16 had $V = 2^1/_3$ and $2^1/_5$. (He very properly judges from these results, that men having such a keen sight ought not to be employed in the railway-battalion or in ambulance or transport service, but should be reserved for the infantry and artillery). Reich also has found that 32 % of the Georgian Infantry in the Caucasus have twice the normal V.

The keen sight of uncivilised races has long been

* H. Cohn, Die Augen der Greise. Tagebl. d. Naturf.-Vers. Breslau 1874.

† H. Cohn, Die Refraction der Augen von 240 atropinisirten Dorfschulkindern. A. v. Graefe's Archiv. XVII. II.

known. Humboldt* relates that his friend Bonpland, who had ascended the basalt cone of the Pichincha, more than three geographical miles distant, was seen by the Indians with the naked eye before he himself could discover him with the aid of a telescope. But no scientific examinations of the *V* of uncivilised races were instituted till a recent date. The presence of the Nubians in the Zoological Garden at Breslau made for the first time such an examination possible. †I tested them with Snellen's point tests, with the result that points which the ordinary European can only count up to a distance of 16 meters were counted by them up to 26 meters, 30 meters and in some instances up to 39 meters. It is, then, nothing extraordinary for a Nubian to have twice the normal *V*. The same result was obtained by Kotelmann‡ and Stein,§ who examined later the eyes of other Nubians and of Laplanders and Patagonians in the Zoological Gardens of Hamburg and Frankfort-on-the-Main respectively.

My experience in Schreiberhau did not enable me to confirm De Haan's‖ statements as to the failure of *V* in old age. De Haan's results were obtained from an examination of not more than 41 persons above 60 years of age, and even of these there were more than 13 with diseased eyes, so that his law as to the rapid failure of *V* after the age of 60 is based upon the examination of only 28 persons. But statistics prove nothing, unless they are many.

At Schreiberhau, which up to that time was a very uncultured mountain village, where few, if any, of the old people had learned to read, so that their eyes were still

* Kosmos, Bd. III. p. 69.

† H. Cohn, Sehschärfe and Farbensinn der Nubier. Centralbl. f. Augenheikunde 1879. Juli.

‡ Berl. klin. Wochenschr. 1879, No. 47.

§ Frankfurter Zeitung 1879, No. 213.

‖ Onderzoekingen naar den invloed van der leeftijd op de gezigtsscherpte. Dissert. inaug. Utrecht 1862.

almost in their normal condition, I was able to establish in the year 1874 that among 100 persons who were more than 60 years of age 34 eyes had $V = 1$ and 88 eyes had $V > 1$. Of the latter, 70 saw the hooked characters up to a distance of between 21 and 30 feet instead of up to 20; 17 up to between 31 and 40 feet, and 1 up to a distance of 42 feet, who thus possessed twice the normal acuity of vision. The average V in that place for 60 or 70 years of age was $^{27}/_{20}$ and for 80 years of age $^{26}/_{20}$.

It would be a most desirable thing to discover a *law* of average power of sight; but in order to do so it would be necessary to examine great masses of persons in towns and country places, among civilised and uncivilised races, in different nations and classes of life, and in valleys and on mountains.

The *illumination* exercises of course a great influence upon acuity of eye-sight. In default of a photometer for the light of day, we are unfortunately left to our own eyesight for all practical purposes; and if with a certain degree of daylight our own normal eye has V depressed below $^5/_6$, we cannot reasonably demand that another person with the same degree of daylight should have $V = {^6/_6}$.

We must add in conclusion that the eye has not only a central but an *excentric* and much more imperfect acuity of vision, for light affects not only the macula lutea (yellow spot) in the centre of the retina, but every part of the retina where we find rods and cones.

We can easily convince ourselves by experiment that, if we close the right eye and with the left eye look at a finger held up in front, we are able at the same time to count the number of fingers held up by another person above, below, to the right or left of this central finger. This is, however, only possible within certain limits, and the extent of surface within

which, while looking at an object placed centrally before the eye, we can perceive at the same time objects placed excentrically is called the *field of vision.*

CHAPTER FIFTH.

Refraction.

The term "refraction of the eye" is used for the refracting power of the eye in repose, without any exertion of the accommodation muscle.

The year 1860 was an epoch in the study of our present subject, for it was early in that year that Donders published his lucid works, which have cleared away the great confusion previously existing among scientific men respecting accommodation and refraction.

Refraction is normal, that is, the axis of the eye is of the normal length, when rays of light which

Fig. XV.

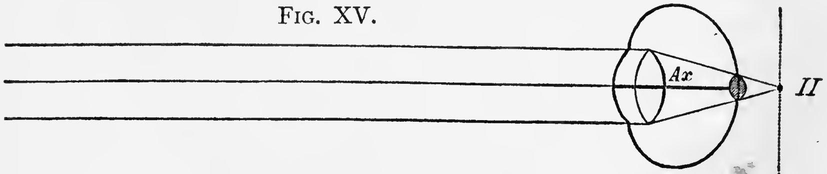


Fig. XVI.

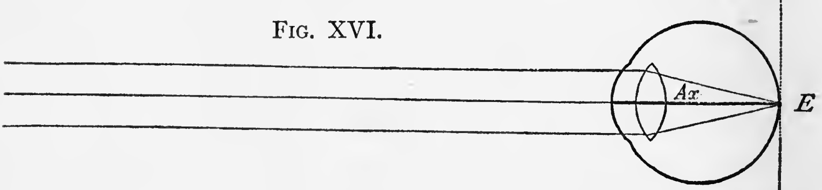
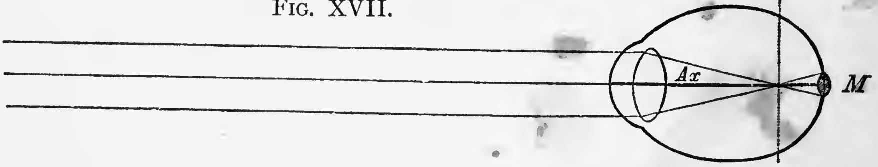


Fig. XVII.



come from infinite distance are focussed exactly upon the retina itself. In such a case we say that the refraction

of the eye is *emmetropic.* (from *emmetros*, "of the right measure" and *ops*, "the eye.") (Fig. XVI.)

Again, the axis of the eye may be too short, so that rays coming from infinite distance are focussed at a point *behind* the retina; this refraction is termed *hypermetropic* ("going beyond the measure") or *hyperopic* (Fig. XVI.). This hyperopia must in no way be confounded with that long sight often noticed in old age, when the patient sees clearly only things at a distance, a defect caused by weakness of accommodation.

Lastly, the axis of the eye may be too long, so that rays from infinite distance are focussed in front of the retina (Fig. XVII.). This kind of refraction is called short-sighted or *myopic* (from *muein*, "to blink" and *ops*, "the eye") because most short-sighted people nearly close their eyelids when they try to look at any distant object.

Thus hyperopia and short sight are true opposites. The one excludes the other.* The hyperopic eye has the axis too short, the short-sighted eye has the axis too long. Hyperopia and myopia are both of them diseases of the eye's refraction, or defects in the length of its axis.

But there is yet another defect caused by a want of symmetry in the curvature of the different meridians of the eye's dioptric system. In this case the eye has different degrees of refracting power in different meridians, so that the rays, instead of meeting in a *point*-focus, meet in a *line*-focus. This fault of refraction we call *astigmatism.* Any one born with this defect, soon becomes conscious of a weakness of vision which leads him to seek the advice of an oculist, and very often it is possible greatly to improve the *V* by specially adapted cylindrical glasses. The examination and diagnosis

* Leaving out of account the defect of astigmatism, mentioned in the next paragraph. It is possible for the same eye to be hyperopic in one meridian and short-sighted in another.—*English Ed.*

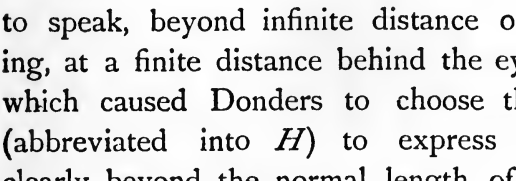
of this defect are not easy; and, as it has no immediate connection with school work, we may content ourselves with simply mentioning it.

CHAPTER SIXTH.

Hyperopia.

In this form of refraction, as we have already explained, rays coming from infinite distance are focussed *behind* the retina, because the axis of the eye is so short that the retina lies in front of the focus of the dioptric apparatus. What rays of light then *do* unite on the retina in a case of hyperopia? Only those which, when they enter the eye, are *converging* to a point *behind* the retina (*m* in Fig. XVIII.). Precisely these are so refracted in the eye that they unite on the retina at *o*. These rays have been called "superinfinite," because their point of origin lies, so to speak, beyond infinite distance or, more strictly speaking, at a finite distance behind the eye. It was this reason which caused Donders to choose the term "Hyperopia" (abbreviated into *H*) to express the power of seeing clearly beyond the normal length of sight, beyond infinite distance.

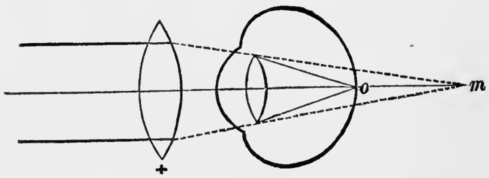
Fig. XVIII.



These superinfinite, convergent rays have no natural existence on earth; but they may be at any moment artificially produced by causing parallel rays to pass through a convex lens so that they become convergent (Fig. VII. *f*). Hyperopia is, therefore, that condition of the eye's

refraction in which the rays of light can only be focussed upon the retina after being passed through a *convex* lens (Fig. XIX.).

FIG. XIX.



The degree of refracting power of a lens which makes the rays of light so convergent that they meet at a point upon the retina is the degree of the hyperopia of the eye. For instance, any one who cannot read the letters on No. 6 of Snellen's Test Types (Fig. XIV.) with the naked eye at a distance of 6 meters, while he can read them easily by looking through a convex glass + 1,0D (or, according to the old inch-measurement, through a glass + $^1/_{40}$), is said to have hyperopia $H = 1D$ (or = $^1/_{40}$ according to the old reckoning); that is, the far-point is 1 meter, or about 40 inches, behind his eye; and any one who needs a convex glass + 10D in order to see clearly at a distance has hyperopia = 10, &c.

Thus the strongest convex glass through which any one can clearly see distant objects gives the degree of his hyperopia.

This test pre-supposes of course that the accommodation of the eye is in absolute repose, which, however, is not always the case in the testing of hyperopic eyes. And for this reason. The hyperopic person cannot see distant objects clearly without the aid of accommodation, while he sees them better the moment he accommodates, or more strongly curves, his lens; for thus, if the degree of hyperopia is slight, he is able to correct the defect due to the form of his eye by placing, as it were, before his reposing lens, by means of accommodation, the proper convex lens. But by this effort he often *loses* in course of time the power of entirely relaxing the accommodation; indeed he almost always

involuntarily contracts the accommodation muscle even in looking at distant objects.

In this way it is possible for young hyperopes to maintain that they cannot see so well through the proper convex glasses as they can without them. The fact is that they make use of accommodation even when wearing the glasses. From the same cause it is very difficult to determine, by the aid of glasses alone, the *true* degree of *H.* To do this, the oculist must make it impossible for the patient to exert the accommodation. The oculist therefore drops *atropine* into the eye. This paralyses the accommodation and makes it possible to estimate by convex glasses the *total* degree of hyperopia, (H^t).

This H^t consists, therefore, of (1) the patent, *manifest* hyperopia (H^m), which was discovered by the glasses alone without the aid of atropine, and (2) the *latent* hyperopia (H^l). which was not revealed until the atropine had been dropped into the eye.

This circumstance is of great importance in testing the eyes of school children (as we shall shew in Chap. VIII.).

There is a form of hyperopia with which a person is able, by the aid of accommodation, to see distant objects clearly even without convex glasses (and without squinting). This is called *facultative* hyperopia (Hf).

Now as the hyperopic person is obliged to exert the accommodation muscle even to see clearly at a distance, he has, as Donders very justly says, to begin, even for far vision, with a *deficit.* In youth, when the accommodation works very readily, a slight degree of hyperopia seldom makes its presence disagreeably felt. It is with more advanced stages of the defect, and in later years, that fatigue is caused by near work through the over strain of the accommodation muscle, a muscle which even for far sight has to make up a deficit.

For the moment, the accommodation muscle answers to the call made upon it, but the effort is too great to

be long sustained, and soon brings on pain in the eye, and pain and a sense of strain above the eye. The sufferer has what is called *accommodative asthenopia,* i.e., loss of power to see near objects, a loss which, however, can easily be remedied by proper convex glasses. Persons afflicted in this way are often thought upon a superficial examination to be short-sighted, or to have weak sight; but a more thorough investigation, conducted with glasses and confirmed by the ophthalmoscope, soon makes it evident that the case is really one of hyperopia.

It is often of great consequence to provide betimes the proper convex spectacles, for *H* easily induces an inward or convergent squint.

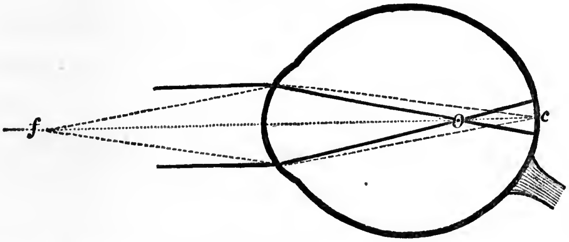
The hyperopic structure is almost always congenital and is often hereditary. It is never acquired by over-exertions or activity; and it causes no very grave dangers to the eye. The annoyances due to it can easily be remedied with the proper spectacles. Hyperopia can never be a subject for preventive treatment—for *prophylaxis.*

CHAPTER SEVENTH.

Myopia (Short Sight).

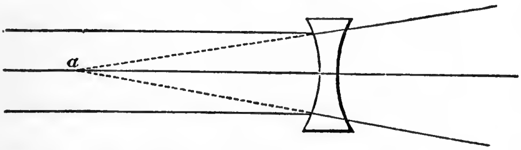
The exact opposite of hyperopia is myopia (abbreviated into *M*). The axis of the eye is too long (Fig. XVII.). Rays of light falling parallel upon the eye from *infinite* distance meet in a point *before* they reach the retina, and, diverging again from that point, form *upon* the retina a circle of diffusion. But rays of light which diverge from a certain point at a *finite* distance meet in a point upon the retina itself. The point from which these rays come is called the "far-point" (Fig. XX., *f* is the far-point, *c* its image upon the retina).

Fig. XX.



It is well known that a *concave* lens (Fig. XXI.) can convert parallel incident rays of light into divergent rays in such wise that they appear to come from a point *(a)* in front of the lens. If this point from which the rays apparently diverge is distant 1 meter in front of the concave lens, we call the lens — 1·0 Dioptric (or $^1/_{40}$ according to the old inch measurement); if the point is 25 centimeters (or $^1/_4$m) distant, the lens is — 4·0*D* (or $^1/_{10}$ by the old inch measurement). The sign — stands for 'concave.'

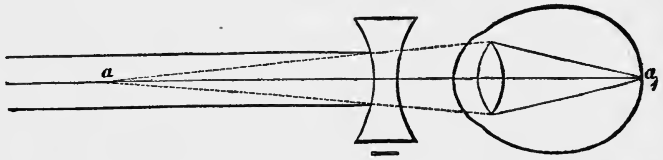
Fig. XXI.



The weakest concave glass, then, through which the eye can clearly see distant objects, is the measure of the degree of the eye's myopia.

For instance, if I am obliged to use a glass — 1*D* (= 1/40 by the old measurement) in order to have $V = 1$, my degree of short sight *(M)* = 1·0 (or 1/40); while if I must use — 4*D*, my M = 4·0 or 1/10). For these concave

FIG. XXII.



glasses have the effect of making parallel rays, or rays from infinite distance, appear to come from a point situated at that distance up to which the short-sighted eye can see clearly, *i.e.*, from the far-point of the eye (Fig. XXII. *a*).

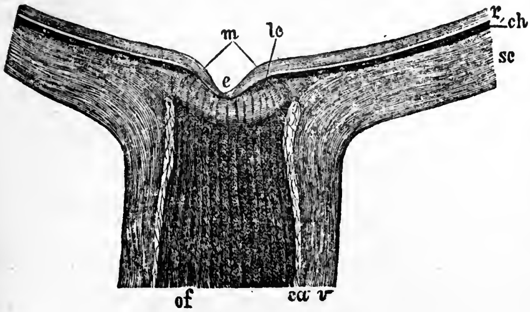
This far-point of a short-sighted eye can be determined directly by *measurement*; the determination is never possible in cases of hyperopia. We have simply to test the short-sighted eye by means of very small print, the so-called 'diamond' type, and find the most distant point at which this print can be easily read. If, for example, the limit is 25 centimeters, a glass of 1/4 of a meter negative focal length, in other words concave 4, or — 4·0 *D*, will improve the sight for distant objects.

But, for this reading test, the eye must be in absolute repose without any use of accommodation, or else the far-point will be placed too near the eye, and a too high degree of M will be inferred; this mistake can of course be obviated by the use of atropine.

The division of M into slight, medium, and high degrees is altogether arbitrary. Generally, however, degrees of short sight are called slight if below $M3$, medium if between $M3$ and $M6$, and high if above $M6$.

Von Arlt, in 1839, was the first to demonstrate anatomically that the lengthened axis was the structural cause of short sight. That part of the eye which is near the back pole is extended. In the normal eye the axis is from 22 to 23 mm. in length. In advanced stages of myopia the length has been found to be 27, 30, 33 mm., and in one instance Donders found it even 37 mm. (In this last case the patient's far-point was only 1 $^3/_{10}$ inches in front of the eye). The short-sighted eyeball is therefore somewhat egg-shaped. The sclera and choroid become more and more thin and transparent towards the back pole; the choroid, indeed, near the optic nerve becomes a thin, colourless membrane insufficiently nourished, in a condition of atrophy; its pigment here is altogether absent or is accumulated in abnormal quantities round the margin of the atrophic parts. The retina is expanded and its vessels are stretched. Beside the optic nerve we often find the so-called *Staphyloma posticum*, which is a bulging out of the coating of the eyeball; this is accompanied by a remarkable alteration in the dividing canal of the optic nerve, as shewn in Fig. XXIV., from a drawing by Donders. For the sake of comparison the normal state of the canal is represented in Fig. XXIII. from Klein's *Augenheilkunde* (Compare Chapter I.).

FIG. XXIII.

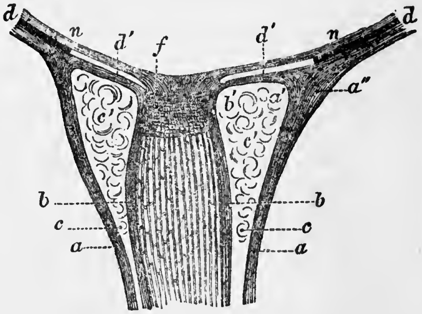


(From Klein's Augenheilkunde.)

The outer sheath of the optic nerve *a* in a short-sighted eye separates from the nerve near the sclera and goes towards *a″*; while the inner sheath *b* closely surrounds the nerve and at *b′* passes out into the sclera. Thus the

thin fasciculus $a' b'$ bounds the loosely woven cellular tissue in the dividing canal c', which is here extremely wide, towards the front and so is obviously very much extended. This thin fasciculus of sclera $a' b'$ is covered in front by the completely worn out atrophic and pigmentless choroid (d').

FIG. XXIV.

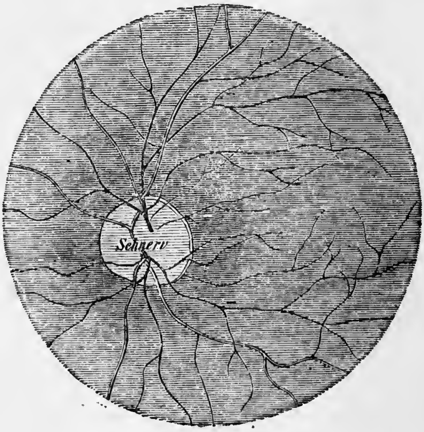


(*From Donders' Refractionsanomalien.*)

In the higher degrees of myopia, even the vitreous body is liquefied, especially towards the back, and is filled with flocculi which float about in it. According to Ivanoff, the accommodation muscle of short-sighted eyes has the linear fibres much more developed than the circular.

Outwardly, there is nothing abnormal in the appearance of a short-sighted eye, except that in very extreme cases a certain stare of the elongated eyeball is now and then noticeable. Apart from this, it is only by means of the ophthalmoscope that the diagnosis of *M*, and even of its degree, can be made with certainty, so that the oculist is quite independent of all subjective data on the part of the patient.

FIG. XXV.

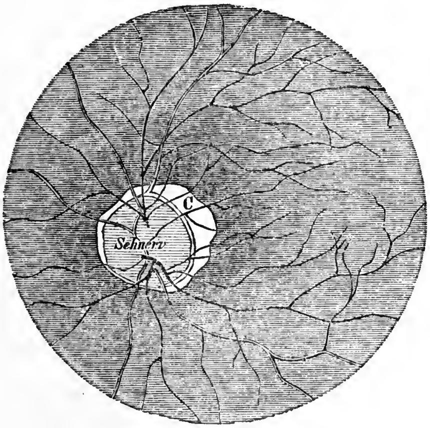


Sehnerv = "*optic nerve.*"

In testing with the ophthalmoscope there is a phenomenon of the highest importance which constantly occurs in a very short-sighted eye, and which is doubtless very closely connected with *M*. It is this. The observer sees with the

ophthalmoscope a figure, usually crescent-shaped and white, at the outer side of the optic nerve. (Fig. XXV. represents the normal appearance of the back-ground of the eye, and Fig. XXVI., after Donders, represents the same back-ground in a short-sighted eye.) This crescent-shaped figure (*C*) is produced by that atrophy of the choroid which was also anatomically demonstrated, and which appears with the ophthalmoscope as a white space, because near the optic nerve the white sclera is distinctly seen through the atrophic pigmentless choroid.

FIG. XXVI.



(From Donders' Refractionsanomalien.)

The crescent - shaped figure may vary greatly in size, the crescent sometimes being very narrow, and sometimes having a breadth equal to a quarter, or even exceeding a half, of the diameter of the optic nerve. It is generally found on the outer side of the nerve, but occasionally above, below, or within it, or in high degrees of *M* it lies in a circle round the nerve. Sometimes a dark band of pigment bounds it from the healthy part of the choroid, and sometimes the transition from the crescent to the choroid is ill-defined. It is not yet established whether this atrophy is really preceded by inflammation of the choroid *(Sclerotico—chorioditis posterior)*; but in some cases a bright red colour is observed at this place in the beginning of the process, and a slight redness is occasionally seen at the margin of the crescent-shaped figure.

In the higher degrees of myopia isolated atrophy is found in other parts of the choroid, of course the danger is very great when the atrophy extends outward and

approaches the yellow spot, for the slightest participation of the posterior coats of the retina at the yellow spot would most seriously affect the central sight. Sometimes, indeed, an actual bulging out of the back of the eyeball is perceived with the ophthalmoscope.

Even in the vitreous body when there is a high degree of short sight, the ophthalmoscope often reveals larger and smaller obscurations and flocculi. In the highest degrees of short sight we see actual *inflammation of the retina* and *choroid*, hæmorrhages in the retina and detachment of the retina.

Short sight is almost always accompanied by atrophy of the choroid, *which increases, as has been proved by experience, with the increase of short sight.*

As a short-sighted person can see only near objects clearly, while distant ones present to him circles of diffusion in place of distinct images, he is (if without spectacles), subject to no little inconvenience, even when in a room. Out of doors his sufferings are far worse. He generally tries to help himself by an unlovely facial contortion, half-closing his eyelids, by which means he to some extent covers the pupil of his eye, and so renders the circles of diffusion smaller and less confusing. It is this blinking (*muein* in Greek) that has given the name Myopia to his malady. Many short-sighted people have accustomed themselves by practice to disentangle, or, as Donders says, to "work away" their circles of diffusion, so that they manage surprisingly well in spite of the confused picture on the retina; while on the other hand those who have accustomed themselves to their spectacles are often painfully at a loss when their spectacles are not at hand.

The myope's acuity of vision does not usually become less except in the higher degrees of myopia; when, with the outstretching of the back pole of the eyeball, the optic cells are drawn further from each other.

In looking at near objects we not only exert the accommodation muscle, but we turn both eyes inwards towards the nose by means of the *musculi recti interni.* In this action the eyes converge. Now in the case of people with normal or emmetropic sight there is a proper joint action of convergence and accommodation, while in the case of short-sighted people the accommodation is spared, because the eyes *already* see objects at a certain short distance *without any aid from accommodation;* while *the convergence muscles are made to do more than their due share of work;* the internal recti are *continually* called into action to turn the eyeball inwards. This over-fatigues them and makes them finally incapable of producing the desired effect; there is *insufficiency* of the internal recti. If they only fail when required to make an unusual exertion, we say there is a *relative* insufficiency of these muscles. This muscular weakness can be easily demonstrated by covering one eye of the patient with the hand and making him look with the other eye at a finger held near him, midway between his eyes: then, if the eye is suddenly uncovered by the withdrawal of the hand, the greater strength of the *outer* muscle will at once be shewn by the eyeball's being turned outwards towards the temple, instead of inwards towards the nose like the eye which was left uncovered.

But this relative insufficiency gradually developes into absolute insufficiency. A feeling of weariness, over-strain and pressure sets in, to which particularly the name *muscular asthenopia* (weak sight occasioned by loss of muscular power) has been given by Von Gräfe. This lack of endurance in vision, produced by fatiguing the convergence muscles, makes itself painfully felt as a hindrance to work. Everything seems confused to the short-sighted person because he sees double, and that in a peculiar manner. In most cases the double sight is disguised

by the letters' appearing to run one into another. (The degree of weakness of the internal recti can be accurately measured by what are called prismatic glasses). Sometimes the patient instinctively tries to relieve himself by only looking with one eye, either closing the other or, when once accustomed to use only one eye, by turning the other outwards. And thus the muscular insufficiency leads to an actual *outward squint*, at first only *periodic*, confined to those times when the sight is directed to near objects, but by-and-by *permanent*, especially in the higher degrees of myopia.

Another disagreeable accompaniment of short-sight is known as *mouches volantes*, i.e., minute shadowy figures, specks and chains, like flying gnats or other small insects. These figures are the shadows of extremely fine obscurations in the vitreous body which short-sighted people perceive more readily on their retina than emmetropic people. In themselves these specks are not at all dangerous, but they are often very troublesome as a hindrance to work; and many persons have become quite hypochondriacal from the constant presence of these shadowy flying figures whose dance is especially perceptible on white paper. In the higher degrees of myopia the eye is conscious of large shadows and spots which correspond to larger obscurations in the vitreous body, and are attended with serious danger.

There are two kinds of myopia to be distinguished, the *stationary* and the *progressive*. In the former the shortness of sight remains unchanged, and, *in the slighter degrees*, it leads to no worse results than a certain awkwardness, and a limitation of the choice of a calling. In the 40th year of life, indeed, at which period the power of accommodation is decreasing, this slight degree of short-sightedness sometimes appears to grow less, a phenomenon which may be explained by several reasons. On the one hand, the lens at this age becomes rather

flatter, so that rays coming from a great distance are focussed upon the retina; on the other hand, as the pupil at this age is always narrower, the circles of diffusion which fall upon the retina are smaller, so that the retinal picture is less indistinct. Observation of these cases of apparent diminution of *M* in old age has often led to a notion utterly false, but very difficult to escape from, that *short-sighted eyes are the best!* Such cases, however, according to the unanimous testimony of oculists, occur unfortunately very seldom.

Wholly different is the case of *progressive* short sight, the mischievous career of which has been most strikingly depicted as follows by the excellent Dutch oculist Donders: "When the elongation of the eye has reached a certain amount, the membranes become so thin, and their power of resistance is so weakened, that it is no longer possible for the elongation to remain stationary; while the pressure inside the myopic eye is generally somewhat increased. The progressive elongation and the progressive short sight advance together and *this advance is an actual disease. I maintain, then, without hesitation, that a short-sighted eye is a diseased eye.* High degrees of short sight have far less prospect of remaining stationary than slight degrees; they increase even at an advanced period of life. In youth almost every kind of myopia is progressive, and its advance is often accompanied with symptoms of irritation. This age is the critical period for the short-sighted eye; if during youth the defect does not greatly increase, it *may* become stationary; but, if it once developes into a higher degree, it is difficult to put limits to its further advance. *It is, then, in youth that injurious exciting influences must be most anxiously guarded against.* I cannot lay too much stress upon this point. *Progressive short sight is in every case ominous of evil for the future.* For, if it remains progressive, the eye soon developes painful symptoms

and becomes less equal to its work; *and not unfrequently at the age of 50 or 60, if not much earlier, the power of sight, either from detachment of the retina, or from hæmorrhage or, lastly, from atrophy and degeneration of the yellow spot, is irrecoverably lost.*"*

Every experienced oculist will unreservedly and entirely confirm this opinion of Donders.

For the wider the spread of the atrophy of the choroid at the posterior pole, the nearer it approaches to the yellow spot, the point at which we see most clearly; and, when once that is attacked by the disease, the central sight is extinguished. Not less dangerous is the detachment of the retina from which so many highly myopic people suffer. This is a disease in which a certain humour is developed between the choroid and the retina. Detachment of the retina is the last step to incurable blindness for, although in very recent operations the attempt to draw off the fluid from behind the retina has now and then been successful, the result has been permanent only in an extremely small number of cases, and the eye, even in those cases, has never been fit for work again.

As short sight is caused by a lengthening of the axis of the eye, it is unhappily incurable, and here also another passage from Donders holds good: "*The cure of short sight belongs to the pia desideria; the more accurate and complete our knowledge of the cause becomes, the more futile appears every hope of finding a remedy, even in the future.*"

This being so, how earnestly should our attention be directed to the *origin*, the *ætiology* of myopia, so that we may at the outset prevent the development of the disease or at least arrest, so far as possible, its further progress. We are the more bound to do this because the *tendency* to short-sightedness is most probably

* Anomalien der Refraction und Accommodation, p. 289.

hereditary; and therefore by neglecting an intelligent prophylactic method we wrong not only the present but also future generations.

There has been much discussion as to the ultimate cause of that lengthening of the axis to which all the evil consequences above described are due, but, up to the present time, the matter has not been fully cleared up. A number of medical men believe that the primary cause is a congenital attenuation of the posterior part of the sclera, and that this attenuation is hereditary; but this theory is opposed by the majority of oculists, for they have actually seen, times without number, children *become* short-sighted whose parents had perfectly normal sight, and who in the first ten years of their life did not show the slightest tendency to myopia. But all authors, whether adherents or opponents of the theory that short sight is congenital, agree that there is a predisposing influence which greatly favours the development of the disease, and that this influence is *the continual looking at near objects, especially under an insufficient light.*

In looking at near objects the accommodation is strongly exerted, the choroid strained, the convergence forced and the head bent forward.

The continued exertion of the accommodation muscle in reading, writing and hand-work leads to a kind of convulsive contraction *(accommodation cramp* or *spasm)*, which often continues even when the eye has looked for some time at distant objects. This contraction forces the lens to assume a more convex form; and so the images which it gives of distant objects are focussed in front of, instead of upon, the retina. There arises in this way an *apparent* myopia called lens-myopia, to distinguish it from the axis-myopia we have described above. If the accommodation muscle obtains sufficient rest and the lens becomes flat again, this kind of myopia may disappear

and emmetropia return. But if the accommodation muscle has not time to recover itself and the lens accordingly cannot properly relax, the transient lens-myopia gradually passes into the *chronic* axis-myopia.

The influence of spasm of the accommodation muscle upon the lens is often manifested in examinations of the eye, when the muscle has been paralysed by atropine. A scholar, for instance, appears to need for distant objects a pair of spectacles — $3D$; but when, by dropping atropine into his eye, the accommodation has been suspended, it is found that he can see distant objects quite well without any spectacles at all, or that he only needs a glass — $1D$. In the former case the accommodation-spasm has simulated a myopia 3 while he is really emmetropic, in the latter case his myopia has appeared to be greater by $2D$ than it really is. I have observed very many such cases of accommodation-spasm and lens-myopia. It is just this spasm that often makes it hard work to determine M accurately by reading tests or by glasses, the ophthalmoscope often shewing a much lower degree of M than the reading test.

The continuous over-straining of the accommodation muscle has also the effect of stretching and pulling the choroid and so of inducing, near the optic nerve, that choroidal attenuation and atrophy which, earlier in this chapter, we have described in detail as a crescent.

The convergence of the eyes, which is a necessity in looking at near objects, requires a constantly heightened activity of the internal recti; while this convergence (and very probably the accommodation also), increases the pressure in the vitreous body, and thus helps on the expansion of the posterior coats of the eye. The muscular activity causes also a tension of the sclera at the outer side of the optic nerve in consequence of which the alterations, described above, in the dividing

canal take place; the sclera, accordingly, is gradually attenuated and becomes more easy to stretch at the back.

Lastly the continuous stooping of the head, necessitated by constant looking at near objects, produces a congestion in the veins which carry off the blood from the eye. Hence arise irritating conditions and over distensions with blood in the back part of the eyeball, and these may bring on a yielding of the choroid and the sclera.

It is true that a high degree of myopia has been found in individuals who have never tried their eyes by minute near work; but such cases are the rarest exceptions and are generally influenced by hereditary tendencies.

The fact that short sight is not *universal* among those who have constant near work with a bad light may partly be explained thus. Many persons who, in spite of near work, have been found emmetropic, were once hyperopic, so that the elongation of the eye's axis has been needed in order to make the sight normal.

This point, which is still a matter of dispute, need receive no further notice here; for all oculists agree that *protracted near work with a bad light is one of the circumstances most favourable to the origin and development of short sight.*

That the statement thus admitted rests on a long experience, gained by means of statistics, will be shewn in the following chapters.

CHAPTER EIGHTH.

Refraction of the Eyes of School Children. *

The earliest notice of the sight of school children is found in a work by James Ware[1], published in 1812. He states that in a military school at Chelsea only 3 children out of 1,300 complained of short sight; on the other hand out of 127 students at Oxford, in the year 1803, no fewer than 32 used eye-glasses or spectacles. "It is possible," adds Ware, "that several were led to use glasses just because it was the fashion; but the number of these is certainly inconsiderable in comparison with those who really saw better with glasses."

Between 1839 and 1850 we learn from Schürmayer[2], that in the Grand Duchy of Baden, inquiries were made in the schools, with the result that, in the 15 educational establishments, 392 scholars out of 2,172 were short-sighted; that is, nearly one-fifth of the whole number. Among the 930 scholars in the higher municipal schools 46 (or about $^1/_{20}$) were *M.* In the fifth and sixth classes (the highest) of the Grammar Schools from $^1/_4$ to $^1/_2$ of the scholars were *M.*

In 1848, Szokalsky[3] instituted inquiries in Paris and found that in the College Charlemagne 1 scholar in 9 was *M*, and in the College Louis le Grand 1 in 7. "This result was the more surprising, because among the 6,300 children of the Parisian Elementary Schools

* The figures near the names of authors refer to the list of publications at the end of this work.

in the 6th and 7th arrondissement, there was not a single short-sighted child to be found." (??) Szokalsky already publishes tables to shew the gradual advance of *M* in the different classes. From the *quarta* to the *prima* in the College Charlemagne the number of *M*'s rose in the proportion 1 : 21, 14, 11, 8, 9; and in the College Louis le Grand, in the proportion 1 : 11, 12, 7, 4. The latter college seems to have been examined by Szokalsky himself, but this is not quite certain. No information is given as to the *degree* of short sight.

Compared with these early statistics, which relate to the complaints of the scholars, or to hearsay, or to very inexact testings, the observations of E. von Jäger[4], published in Vienna in 1861, deserve special mention as breaking fresh ground. Von Jäger was the first to examine the children for himself with the ophthalmoscope. He found in an orphanage, among boys from 7 to 14 years old, 33 per cent. with normal sight, 55 *M* and 12 *H*. On the other hand, in a private school, among the children from 9 to 16 years old, he found 18 per cent. normal, 80 *M* and 2 *H*. He also noticed the different degrees of short sight, although he did not tabulate these according to classes. His materials, too, as he himself says, were too scanty for a general conclusion.

In the summer of 1865, Professor Rüte[5] personally examined the eyes of 213 children sent to him by the teachers of 2 National Schools, in Leipzig, as suffering in the eyes; the whole number of scholars in the two schools was 2,514. Of the 213, he found that 107 had inflammations of the eyelids, the conjunctiva and the cornea; 48 had short sight and 55 hyperopia. The number of *M*'s thus varied from 2 to 3 per cent. Of course there were numerous cases of lower degrees of *M* of which Rüte took no notice.

As in the earlier investigations before Jäger no regard

had been paid to the difference between H and M, and as, afterwards, the number of scholars examined was in no case large enough to exclude accidental error, and the scholars were moreover not examined by medical men personally; and as neither the degrees of short sight with reference to the different classes, nor the locality, with the school desks, had been taken into account, I[6] undertook in the year 1865-1866 the examination of 10,060 school children as follows:—I first held a preliminary examination with test-types of all the scholars in the department, and then a special examination with the ophthalmoscope of those children who could not read the test-types at the normal distance. Besides this, I measured the height of every scholar in the 166 departments and all the dimensions of the desks that I found, and I added a table of the lighting of the schools (see Chapter XIII.). For each scholar I recorded the age, the number of years he had been at school, the result of the reading test, the spectacles finally fixed on, and the result of the ophthalmoscope.

In this manner I examined 5 village schools (in Langenbielau, in the district of Reichenbach in Silesia), 20 town elementary schools, 2 middle schools, 2 higher schools for girls, 2 real schools, and 2 gymnasia in Breslau; altogether 10,060 children, that is 1,486 village children and 8,574 town children. I found that 5·2 per cent. of the village children, and 19·2 per cent. of the town children, had defective sight. Altogether there were 17·1 per cent., or nearly one-fifth of the total number, *ametropic*. This percentage would doubtless have been considerably greater if I had not excluded from my tables, as practically of too little account, every case of $M < {}^{1}/_{36}$, or about $< 1D$.

I found 83 per cent. E (with normal sight), 13 per cent. with defective refraction (10 per cent. of them being M), and 4 per cent. suffering from various other

diseases of the eye. The frequency of myopia is shewn by the following table:—

I noted in	5	village schools	1·4 per cent. *M.*
	20	elementary schools ...	6·7 „ „ „
	2	higher schools for girls ...	7·7 „ „ „
	2	middle schools	10·3 „ „ „
	2	real schools	19·7 „ „ „
	2	gymnasia...	26·2 „ „ „

that is, out of 10,060 children, 1,004*M* = 9·9 per cent.

It was evident from this, (1) that *in village schools the percentage of short sight is very low, while in the town schools the number of short-sighted scholars constantly increases with the grade of the school, from the lowest grade to the highest*: so that the number of short-sighted children is in direct relation to the length of time during which the children's eyes are worked.

In the town elementary schools there were 4 or 5 times more *M*'s found than in the village schools. In the latter the number of *M*'s varies generally from 0·8 to 3·2 per cent., while in the 20 elementary schools it varies from 1·8 to 15·1 per cent. In the various real schools and gymnasia the difference was only 2 — 4 per cent.

It was evident (2) that *in every school the number of short-sighted children increased from class to class.* On an average the number of *M*'s in the third, second, and first classes of the village schools was 1·4, 1·5 and 2·6 per cent. On the other hand the average result in the same classes of the 20 elementary schools was 3·5, 9·8 and 9·8 per cent.

In the real schools the *M* percentages from the sexta to the prima were 9, 16·7, 19·2, 25·1, 26·4, 44, in the gymnasia 12·5, 18·2, 23·7, 31, 41·3, 55·8. *That is, more than half of the highest class are short-sighted.*

Of course there were here and there slight exceptions to this increase, a lower percentage being sometimes found, for instance, in the first class than in the second,

but this was chiefly owing to the fact that usually only a small number of scholars were present in the highest classes, so that a single case of *M* gives a very different percentage in them from what it gives in the fuller lower classes. But with larger numbers and on an average, the increase constantly shewed itself.

In the village and elementary schools there was found no essential difference between the sexes; but the large contingent of *M*'s found in the gymnasia and real schools made the number of *M* boys in the 10,060 children twice as many as the number of *M* girls.

The *M* number was found to increase not only with the rank of the class but with the number of years spent at school. I found no *M* in the village schools among children who had only been half a year at school; while of those who were in their fourth or fifth year the *M* number was 1·6 per cent. for village school children, 8·2 per cent. for town elementary scholars, 11·9 per cent. for middle school children, and 14·5 per cent. for scholars in real schools and gymnasia. If I added together, respectively, the first 4 years at school, the second 4, and the last 6 years (corresponding nearly to the 7th-20th years of life), I found 4·5, 9·6, and 28·6 per cent. *M*.

There appeared (3) unmistakeably in the 166 classes of the 33 schools *an increase in the degree of M from class to class in all the schools.* I selected at that time 6 stages of *M*. First $M\,{}^1/_{35}$ to $M\,{}^1/_{24}$ (about 1 *D* to 1·5 *D*); 2nd, $M\,{}^1/_{23}$ to ${}^1/_{16}$ (= 1·75 — 2·25); 3rd, $M\,{}^1/_{15}$ to ${}^1/_{12}$ (2·5 — 3); 4th, $M\,{}^1/_{11}$ to ${}^1/_{8}$ (3·25 — 4); 5th, $M\,{}^1/_{7}$ (*M* 5), and 6th, $M\,{}^1/_{6}$ (*M* 6). The 1,004 *M*'s were distributed over these stages as follows: 466, 303, 150, 76, 6, 3. I never found a higher stage than $M\,{}^1/_{16}$ in any village school. On the whole, nearly half of the *M*'s were weaker than $M\,{}^1/_{24}$. $M\,{}^1/_{7}$ and ${}^1/_{6}$ were only found in gymnasia and real schools. Among boys

the higher stages of M were more frequent than among girls. (For details the reader is referred to the essay from which I am quoting).

The degree of M advances also with the age of the scholar; the *higher* degrees, however, are more frequently found in the first four years of school life than in the 7th-10th years of life.

To find the *average degree of short sight in any class*, I added up the degree-numbers of myopia found in the class, and divided by the number of myopes. The mean of these average degrees for various classes gave the *average degree of myopia in the school;* and the mean of these last averages for various schools of the same sort, gave *the average degree of M for that sort of school.*

Thus I found the average degree of M in 5 village schools to be $= \frac{1}{24{\cdot}4}$, in 20 elementary schools $= \frac{1}{22{\cdot}7}$, in 2 middle schools $= \frac{1}{21{\cdot}9}$, in 2 real schools $= \frac{1}{19{\cdot}6}$, and in 2 gymnasia $= \frac{1}{18{\cdot}7}$. The average degree of all M's was $M = \frac{1}{21{\cdot}8}$. *So that the average degree of M rises constantly from the village schools to the gymnasia.*

That it also rises from the lowest class to the highest is evident from the following table which gives (in the old inch-measurement) the average far-points from the 6th to the 1st class:—

In real schools: 23·7, 20, 19·8, 19·1, 18·8, 16·7″

In gymnasia: 22·4, 20·6, 18·9, 18, 15·7, 17·1″

The average degree of M differs but slightly for the two sexes. I never found a higher degree than M $^1/_6$, except when accompanied by complicating eye disorder.

Among the 1,004 M there were 200 cases of *staphyloma posticum.* In the village schools, but only in the highest class, the cases amounted to 0·2 per cent. of the total number of scholars; in the elementary schools they increased to 0·5 per cent., in the higher girls' schools

they were 0·3 per cent. of the total number of girls, and 4·6 per cent. of the short-sighted ones; in the middle schools they were 1·4 per cent. of the total number, and 13·6 per cent. of the short-sighted scholars; in the real schools 7·1 per cent. of the total number, and 36 per cent. of the short-sighted scholars, and in the gymnasia 6·9 per cent. of the total number, and 26 per cent. of the short-sighted scholars.

The number of these cases of staphyloma increased with the age of the myopes. *The higher the degree of M the more frequently it was accompanied with staphyloma posticum*, so that the percentages of staphyloma in the 6 stages of *M* mentioned above were as 3 : 17 : 48 : 65 : 71 : 100. It was quite an exception to find slight degrees of *M* attended with staphyloma, or high degrees of *M* without staphyloma.

Hyperopia I found in 239 children (or 2·3 per cent.) and as much in girls as in boys. For one case of *H* there were always more than 4 cases of *M*. Of course this calculation is based upon manifest *H* alone; in this *H* there was no important increase or decrease from school-year to school-year or from school to school. The degree of *H* varied from $H\,{}^1/_{60}$ to $H\,{}^1/_8$; in the majority of cases from $H\,{}^1/_{40}$ to $H\,{}^1/_{20}$; there were only 7 cases of $H > {}^1/_{12}$. The average degree in the village schools was ${}^1/_{34}$, in the elementary schools ${}^1/_{32}$, in the higher girls' schools ${}^1/_{26}$, in the middle schools ${}^1/_{37}$, in the real schools ${}^1/_{28}$, and in the gymnasia ${}^1/_{24}$. The average degree of all the cases of *H* was ${}^1/_{30}$. Only 9 hyperopes wore convex glasses. Out of the 239 *H* 158 had an inward squint *(strabismus convergens)* = 66 per cent. of *H* and 1·5 per cent. of the total number of children. Of the *H* boys 67 per cent., and of the *H* girls 63 per cent., squinted; in the higher girls' schools 3·9 per cent., in the higher boys' schools only 1·1 per cent. The squint was in the right eye in

104 cases, in the left in 30; in 23 cases both eyes squinted by turns. In 44 children the squint was periodic, in 114 it was continual. In 80 per cent. of those scholars who squinted I found medium degrees of H ($^1/_{40} — ^1/_{20}$). The V of the squinters varied from $^9/_{10}$ to $^1/_{200}$.

In 23 children I noted *astigmatismus regularis.* Only one of them wore cylindrical glasses.

The number with some eye-disease amounted to 396 = 4 per cent. These children furnished 490 cases of eye-disease, of which only 211 were cases of spots upon the cornea *(maculae corneae).* The other cases were of scrofulous inflammation of the cornea in children of the poorest classes attending elementary schools.

The wish expressed by me, on the publication of these results in the year 1867, that similar investigations should be set on foot in other places, has been amply fulfilled. A great mass of statistics now exists, collected by competent observers in other towns, statistics which have the advantage, in the first place, of taking into account the degrees of $M < ^1/_{36}$ (or $< 1\ D$), practically insignificant, but theoretically most important. The percentages of M in the following tables are therefore generally much higher than mine.

Besides this, some of these oculists have examined each eye separately, instead of both together; other writers have tested *all* the children, even those whose sight was apparently normal, with the ophthalmoscope.

It would, however, lead us too far, to give here all the details of these statistics, which relate to the eyes of more than 50,000 school children; especially as they collectively confirm the principal results, above described, of my own examinations, and differ, too, but slightly from my results as to the manner in which they have been obtained. Moreover many of these researches are only of local interest. On the other hand, several new

points of view for which we are indebted to the more recent researches, require to be dwelt on somewhat fully. But before attempting this, I must be allowed to insert the following tables, which will give an idea of the immense activity of writers labouring in this department of school hygiene.

(The sources whence the numbers in these tables are derived will be found in the literary catalogue at the end of this book).

TABLE No. I.

PERCENTAGE OF SHORT-SIGHTED SCHOOL CHILDREN.

Year.	Examiner.	Locality.	School.	Number of children examined.	Percentage of short sight.
1861	E. von Jäger[4]	Vienna.	Orphanage for Boys	50	55
			Private School	50	80
1865 1866	H. Cohn[6]	Breslau	33 Schools:	10060:	10
			5 Village Schools	1486	1
			20 Town Elementary Schools	4978	7
			2 Middle Schools	426	8
			2 Higher Girls' Schools	834	10
			Holy Ghost Real School	502	18
			Zwinger Real School	639	21
			Elizabeth Gymnasium	552	24
			Magdalen Gymnasium	663	28
1868	Thilenius[7]	Rostock	Gymnasium	314	31
1870	Schultz[8]	Upsala	Gymnasium	431	37
1870	H. Cohn[9]	Breslau	Frederick Gymnasium	361	35
			The same 1½ years later	138	51
1871	Erismann[10]	St. Petersburg	8 Gymnasia; 4 German Schools; 1 Girls' Gymnasium	4368:	30
			Boys' Schools	3266	31
			Girls' Schools	1092	27
			Russians	2534	34
			Germans	1834	24
			Day Pupils	397	35
			Boarders	918	42
1871	Maklakoff[11]	Moscow	? (not indicated in the German reports)	759	33
1871	H. Cohn[12]	Schreiberhau	Village School	240	1
1873	Krüger[13]	Frankfort on the Main	Gymnasium	203	34
1873	H. v. Hoffmann[14]	Wiesbaden	4 Schools:	1227:	20
			Prepy. and Municipal S.	568	20
			Higher Girls' School	403	20
			Gymnasium	256	38
1874	A. von Reuss[15]	Vienna	Leopoldstadt Gymnasium	409	42
			The same one year later	211	52
1874	Ott u. Ritzmann[16]	Schaffhausen	Gymnasium	122	44
1874	Ott[17]	Schaffhausen	Real School	164	13
1874	Burgl[18]	Munich	Girls' High School	179	49
1874	Dor[19]	Berne	Cantonal Real School	143	35
			Cantonal Classical School	117	28
			Town Real School	170	25
1875	Conrad[20]	Königsberg	3 Gymnasia	1518	22*

* 32 per cent. by test types found to be *M*; 22 by ophthalmoscope.

TABLE NO. I.—*(Continued.)*

Year.	Examiner.	Locality.	School.	Number of children examined.	Percentage of short sight.
1875	Callan[21] .	New York .	Negro Schools: .	457:	3
			Primary Department .	?	0
			Grammar Department .	?	5
1876	Scheiding[22] .	Erlangen .	Gymnasium . . .	175	55
1876	Koppe[23] .	Dorpat. .	Kindergarten . .	31	0
			National School . .	103	2
			Preparatory School. .	136	11
			Gymnasium . . .	396	30
1876	Pflüger[24] .	Lucerne .	Lower School, Boys' .	808	5
			Lower School, Girls' .	879	8
			Real School . . .	74	36
			Gymnasium . . .	85	52
1876	A. von Reuss[25] .	Vienna .	Leopoldstadt Gymn'sium, 3 examinations . .	252	50
			National School . .	240	11
1876	Loring & Derby[26]	New York .	Primary School . .	205	7
			District School . .	249	12
			Normal School . .	679	27
			Ch'n of German parents	?	24
			,, American ,,	?	20
			,, Irish ,,	?	14
1877	Emmert[27] .	Berne . .	15 Schools: . .	2148:	12
			Lerber Gymnasium .	219	21
			Burgdorf Gymnasium .	158	10
			Solothurn Gymnasium .	112	23
			Training College for Teachers, Münchenbuchsee	113	8
			New School, Girls', Berne	292	15
			Municipal School, Girls', Berne . . .	239	15
			Girls' School, Burgdorf .	89	6
			Elementary Schl, Burgdorf	126	1
			Primary and Secondary School in St. Immer .	220	5
			Primary and Secondary School in Locle . .	233	10
			Primary and Industrial School in Chaux de Fonds	240	11
			4 Watchmakers' Schools .	107	12
1877	Kotelmann[28] .	Hamburg .	Johannes Gymnasium .	413	38
			Reform. Real School .	232	26
			Municipal High School .	310	25

TABLE No. I.—*(Continued.)*

Year.	Examiner.	Locality.	School.	Number of children examined.	Percentage of short sight.
1877	Kotelmann[28] .	Hamburg .	Pracht's Private High School, Girls'	104	17
			Zimmermann's ditto .	218	22
			Training School for Mistresses . . .	45	42
			Training School's National School . . .	296	12
			Gymnasium in Wandsbeck	283	19
1877	Classen[29] . .	Hamburg .	Johannes Real School .	402	41
1877	O. Becker[30] .	Heidelberg .	Gymnasium . . .	287	35
			Municipal School . .	261	13
1877	Williams[31] . .	Cincinnati .	District Schools . .	630	10
			Middle Schools . .	210	14
			High Schools . . .	210	16
1877	Agnew[32] . .	New York .	New York College . .	579	39
			Brooklyn Polytechnic Institute . . .	300:	19
			Academic Department .	142	10
			Collegiate Department .	158	28
1877	H. Derby[33]. .	Boston .	Amherst College . .	1880?	28
			Harvard . . .	122	29
1878	Niemann[34] . .	Magdeburg .	Cathedral Gymnasium .	325	48
			Convent School . .	388	44
1878	Seggel[35] . .	Munich .	Cadets' Real Gymnasium	?	31
1878	Dor[36]. . .	Lyon . .	Lyceum: . . .	1016:	22
			Day Scholars . . .	683	18
			Day Boarders . .	129	29
			Boarders . . .	204	33
1878	Reich[37] . .	Tiflis . .	Four Schools: . .	1258:	29
			Classical Gymnasium .	?	37
			Girls' Gymnasium . .	?	25
			Municipal School . .	?	10
			Training Sch. for Teachers	?	12
			Russians in the above 4 Schools . . .	?	30 30 2 8
			Armenians ditto . .	?	38 24 14 25
			Georgians ditto . .	?	45 21 14 10
1878	Haenel[38] . .	Dresden .	Royal Gymnasium . .	476	49
1879	Just[39] . .	Zittau . .	Gymnasium . . .	194	48
			Real School . . .	293	40

TABLE NO. I.—*(Continued.)*

Year.	Examiner.	Locality.	School.	Number of children examined.	Percentage of short sight.
1879	Just[39] . .	Zittau . .	Select Girls' School .	193	24
			Municipal School, Girls'	202	14
			Municipal School, Boys'	347	15
1879	Nicati[40] . .	Marseilles .	6 (?) Schools . . .	1717	15
			Boys' Primary School .	?	8
			Girls' „ „ .	?	7
			Jews' Boys' School. .	?	15
			Jews' Girls' School. .	?	10
			Great Lyceum, Boarding and Day Boarding .	?	35
			Small Lyceum ditto .	?	22
			Lyceum (externes surveillés) . . .	?	16
			Lyceum (externes libres)	?	62
1879	Priestley Smith[41].	Birmingham.	?(not in German report).	1636	5
			Training College Students	357	20
1880	Netoliczka[42] .	Graz . .	Gymnasium . . .	653	35
			Real School . . .	278	33
			Municipal National Schl., Boys' . . .	2350	10
			Village School, Boys' .	361	4·
			Municipal Nat. Sch., Girls'	2238	13
			Village School, Girls' .	299	8
1880	Florschütz[43] .	Coburg. .	6 Schools in the year 1874:	2041:	21
			Municipal Boys' School .	694	12
			Municipal Girls' School .	782	14
			Gymnasium . . .	177	51
			Real School . . .	260	42
			Alexandrina School .	112	25
			Training School . .	16	43
			The same 6 schls. in 1877:	2323:	14
			Municipal Boys' School .	786	4
			Municipal Girls' School .	830	7
			Gymnasium . . .	182	49
			Real School . . .	290	35
			Alexandrina School .	147	31
			Training School . .	28	32
1881	A. Weber[41]. .	Darmstadt .	Gymnasium . . .	509	44
			Real School . . .	354	41
			High School, Girls' .	265	42
			Middle School, Girls' .	270	27

TABLE No. II.

PERCENTAGE OF SHORT-SIGHTED SCHOLARS IN THE DIFFERENT CLASSES.

Examiner.	Year.	Locality.	School.	Number Examined.	Percentage of Short Sight in Class. IX.	VIII.	VII.	VI.	V.	IV.	III.	II.	I.
H. Cohn. ($M > 1\ D$)	1865 1866*	Breslau	Five Village Schools	1486	—	—	—	—	—	—	1	2	3
			20 Municipal Elementary Schools	4978	—	—	—	—	—	—	3	4	10
			2 High Schools, Girls'	834	—	1	2	7	8	6	16	12	19
			2 Middle Schools	426	—	—	—	0	10	6	13	9	15
			Holy Ghost Real School	502	—	—	—	7	12	25	27	25	59
			Zwinger " "	639	—	—	—	11	21	13	23	28	29
			Elizabeth Gymnasium	532	—	—	—	11	17	19	31	48	65 !
			Magdalen Gymnasium	663	—	—	—	14	19	28	30	35	47
Thilenius	1868	Rostock	Gymnasium	314	—	—	—	11	16	33	36	40	41
H. Cohn.	1870	Breslau	Frederick Gymnasium	361	—	—	13	21	27	35	53	60	42
Erismann	1870	St. Petersburg	13 Institutions, including 7 Gymnasia	4358	14	16	22	31	38	41	42	43	42
Schulz	1870	Upsala	Gymnasium	431	—	14	26	15	37	26	44	53	54
Krüger	1871	Frankfort-on-the Main	Gymnasium	203	—	4	20	40	17	35	55	54	64 !
Von Hoffmann	1873	Wiesbaden	Gymnasium	256	—	—	19	24	25	32	50	58	48
			Municipal School	568	—	4	1	14	13	21	30	29	23
			High School, Girls'	403	—	6	9	14	27	28	39	37	27
Von Reuss	1872	Vienna	Gymnasium	409	—	28	41	49	48	40	50	61	58
	1873		The same	389	—	37	37	42	46	45	55	69	75 !
	1875		The same	252	—	—	—	50	50	45	41	58	55
Burgl	1874	Munich	High School, Girls'	179	—	—	—	—	—	—	44	46	62 !
Dor	1874	Berne	Cantonal School, Real	143	—	—	10	19	28	60	54	50	60
			" " Classical	117	—	14	17	28	15	33	35	50	54

TABLE NO. II.—(*Continued.*)

Examiner.	Year.	Locality.	School.	Number Examined.	Percentage of Short Sight in Class. IX.	VIII.	VII.	VI.	V.	IV.	III.	II.	I.
Dor	1874	Berne	Municipal Real School	170	—	—	16	27	12	18	40	31	66 !
Conrad	1875	Königsberg	3 Gy'sia, ophthalmoscope	1518	—	4	6	9	14	19	34	37	52
			(with test types only)		—	(11)	(15)	(20)	(22)	(28)	(44)	(55)	(62)
Scheiding	1876	Erlangen	Gymnasium	175	20	20	31	38	72	58	84	88	80 !
Koppe	1876	Dorpat	Gymnasium	792	—	—	—	—	—	21	43	49	61 !
Pflüger	1876	Lucerne	Boys' and Girls' School	1687	—	—	—	1	4	4	7	10	14
			Gymnasium and Real School	159	—	—	17	32	45	43	57	62	63 !
			Gymnasium	287	—	—	—	4	?	?	?	?	100 !
O. Becker	1877	Heidelberg	Johannes Gymnasium	413	—	—	—	15	22	45	40	48	61 !
Kotelmann	1877	Hamburg	Reform. Real School	232	—	—	—	16	21	32	29	45	45
			Municipal High School	310	—	—	—	12	28	21	30	25	38
			Zimmermann's Girls' High School	218	—	10	12	24	26	35	41	24	28
			Wandsbeck Gymnasium	283	—	—	—	9	18	23	24	45	25
Emmert	1877	Berne	Gymnasium	219	8	28	27	20	56	56	67	71	50
		Burgdorf	Gymnasium	158	—	5	10	5	6	8	25	33	25
		Solothurn	Gymnasium	112	—	—	6	33	10	20	52	30	30
		Berne	Municipal School, Girls'	239	9	4	16	9	12	25	14	19	44
		Burgdorf	Girls' School	89	—	—	—	—	3	4	0	11	15
			Elementary School	126	—	—	—	—	—	—	0	0	1
		Berne	New School, Girls'	292	6	11	10	8	17	12	9	23	39
		St. Immer	Secondary School, Boys'	92	—	—	—	—	4	3	10	0	0
			Secondary School, Girls'	98	—	—	—	—	7	8	4	12	0
		Chaux de Fonds	Industrial School, Boys'	71	—	—	—	—	—	2	10	12	50
			Industrial School, Girls'	92	—	—	—	—	—	—	20	9	23

TABLE NO. II.—(*Continued.*)

Examiner.	Year.	Locality.	School.	Number Examined.	Percentage of Short Sight in Class. IX.	VIII.	VII.	VI.	V.	IV.	III.	II.	I.
Emmert	1877	Locle	Secondary School, Girls'	50	—	—	—	—	—	—	8	23	29
Classen	1877	Hamburg	Johannes Real School	402	—	—	—	29	24	40	46	71	50
Niemann	1878	Magdeburg	Cathedral Gymnasium	325	—	—	—	23	29	39	63	58	75 !
			Convent School	388	—	—	—	23	27	42	47	56	70 !
Haenel	1878	Dresden	Royal Gymnasium	476	—	—	—	33	34	51	54	64	71 !
Just	1879	Zittau	Boys' School	347	—	—	—	5	12	13	17	22	36
			Girls' Elementary School	202	—	—	—	12	13	8	12	14	28
			High School, Girls'	193	—	—	7	8	35	20	35	35	31
			Real School	293	—	—	—	24	21	35	47	52	57
			Gymnasium	194	—	—	—	34	31	37	53	72	65 !
Netoliczka	1880	Graz	Government Higher Gymnasium	167	—	—	—	—	—	7	11	22	30
			Government Real School	127	—	—	9	8	13	7	18	53	62 !
			Commercial School	126	—	—	—	—	—	12	24	24	22
			Girls' Lyceum	129	—	—	—	24	9	25	26	14	31
Florschütz	1880	Coburg	Gymnasium	177	—	—	—	24	37	49	69	86	80 !
			Real School	260	—	—	—	33	33	47	37	55	62
A. Weber	1881	Darmstadt	Gymnasium	509	—	—	—	24	31	47	45	54	56
			Real School	354	—	—	—	51	28	31	38	47	51
			High School, Girls'	265	—	—	10	40	43	45	44	44	55
			Middle School, Girls'	270	—	—	—	—	29	21	15	42	45
			Total	31529	—	—	—	—	—	—	—	—	—
Average of the 24 Gymnasia and Real Schools marked in the following curve diagram				9344	—	—	—	22	27	36	46	55	58

Among the investigations which present new points of view, that of Erismann[10] (1871) demands the first place. He tested in St. Petersburg with Snellen's types 4,368 scholars, at 20 feet distance from the types, and found 30·2 per cent. *M*, 26 per cent. *E*, 43·3 per cent. *H*, and 5 per cent. *amblyopic* or weak-sighted. The enormous percentage of hyperopic children was surprising. These were cases of facultative-manifest hyperopia, occurring in scholars who could see distant objects as clearly without convex glasses as with them. Most of the *H* cases were found in the lowest classes, and their number gradually decreased from the lowest to the highest class In my own examination I had paid but little attention to the number of hyperopic cases, because the absolute percentage of *H* cannot be ascertained without atropine, which I was not allowed to use, as, of course, neither was Erismann. Nevertheless Erismann rightly conjectured that *H is the normal condition of the eye in youth, and that only the minority of cases remain hyperopic in after life, the majority becoming short-sighted after passing through emmetropia or normal sight.*

He supported his hypothesis with the following table:

Class.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
M	13·6	15·6	22·4	30·7	38·4	41·3	42	42·8	41·7
H	67·8	55·8	50·5	41·3	34·7	34·5	32·4	36·2	40
E	18·6	28	26·4	27·3	26·4	24·2	25	21	18·3
Total.	100	100	100	100	100	100	100	100	100

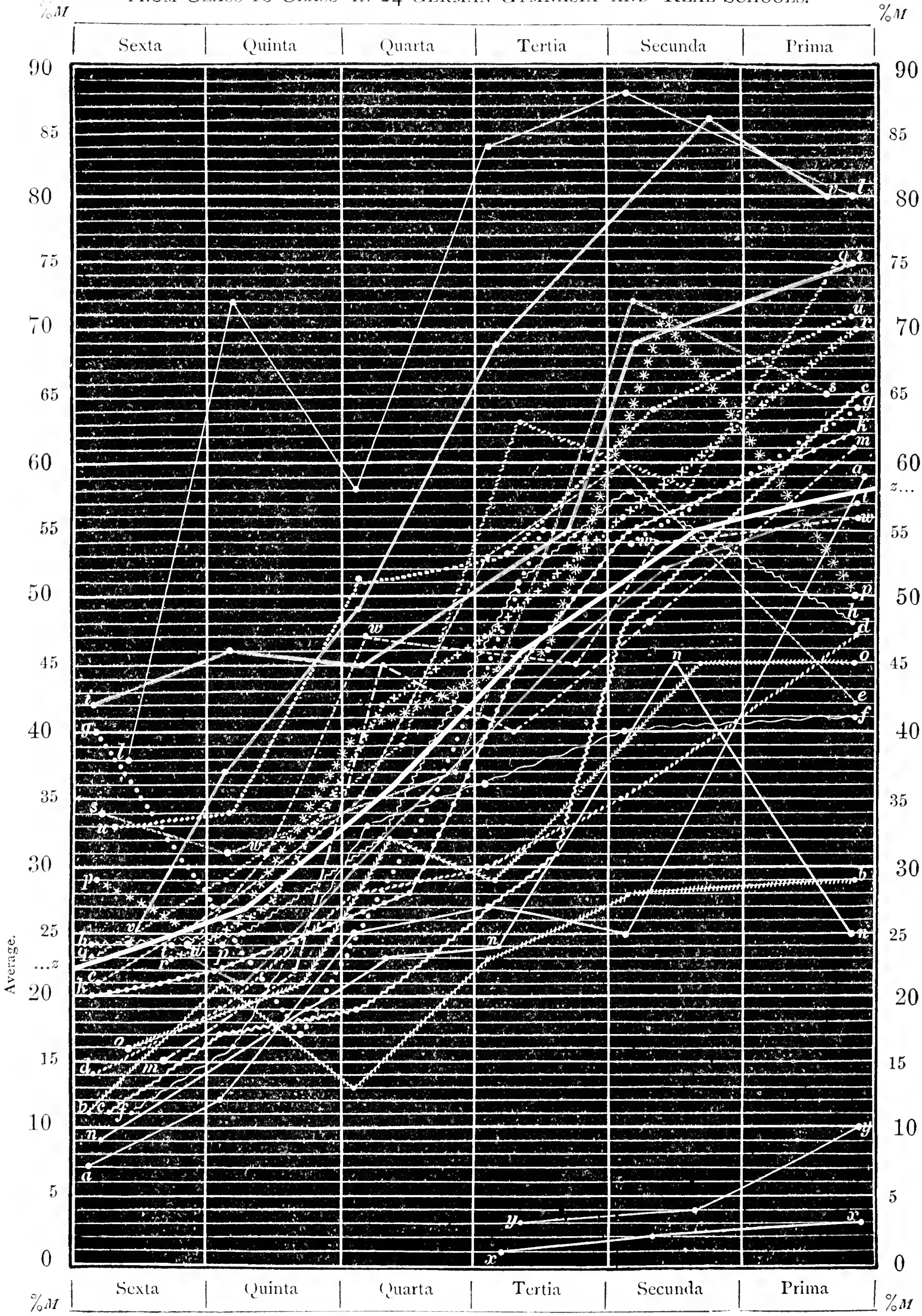
Unfortunately Erismann tells us nothing as to the *degree* of *H*. Moreover the indications of facultative *H* are well known to fluctuate; on one day + 1·0, on another + 1·5 is pointed out as the best glass, according as the accommodation is more or less relaxed behind the glass.

Erismann's tables of short sight agree very closely with my own; he often assumed accommodation spasm when *V* was not perfect and there was much capillary

hyperæmia of the optic nerve. He found $V = 1$ or > 1 only in 85 per cent.; $V < 1$ and $> 2/3$ in 6·8 per cent; and $V < 2/3$ in 7·6 per cent. In the higher degrees of *M* Erismann noted a diminution of *V;* but here he quite overlooked[45] the fact that the stronger concave glasses would of themselves lessen *V* because of their lessening objects generally. Among 1,245 *M*'s Erismann's finding as to atrophic changes in the choroid was thus: *none* in 5 per cent., moderate in 71 per cent., great in 24 per cent.; these cases of atrophic choroidal change were more frequent in the higher classes than in the lower, and they increased in number from 14 to 38 per cent. with the school-years. With higher degrees of *M* than $1/12$ he invariably found *staphyloma posticum,* and in as many as 70 per cent. of the cases where *M* was $> 1/6$ there were great atrophic choroidal changes.

Erismann also noted muscular insufficiency in 32·6 per cent. of all the *M*'s. Extreme insufficiency and relative outward squint were more common in the elder classes and higher schools than in the lower. Even with the lowest degrees of *M* there were 23 per cent. disturbances of the muscular equilibrium, but their number increased with the degrees of *M.*

CURVE DIAGRAM SHEWING THE INCREASE OF SHORT-SIGHTED SCHOLARS FROM CLASS TO CLASS IN 24 GERMAN GYMNASIA AND REAL SCHOOLS.



Percentage of short-sighted scholars.

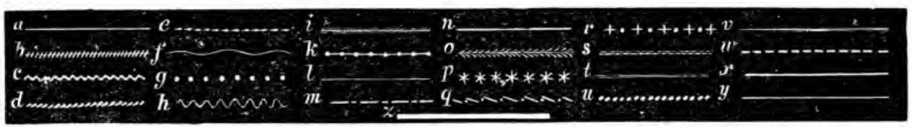
TABLE No. III.

Average Degree of Short Sight in the different Classes. The figures refer to the average number *(D)* of the glasses used by the Scholars of these Classes.

Examiner.	Year.	Locality.	School.	No. Exmd.	VII.	VI.	V.	IV.	III.	II.	I.	Average Degree of Short Sight.
H. Cohn	1865	Breslau	5 Village Schools	1486	—	—	—	—	1·6	1·7	1·8	1·7
			20 Elementary Schools	4978	—	—	—	—	1·7	1·8	1·8	1·8
			2 High Schools, Girls'	834	—	1·7	1·8	1·6	1·7	1·8	1·7	1·7
			Holy Ghost Real School	502	—	1·8	2·0	1·8	1·9	1·9	2·6	1·9
			Zwinger Real School	639	—	1·7	1·8	2·0	2·0	2·0	2·0	1·9
			Elizabeth Gymnasium	532	—	1·8	1·9	2·0	2·2	2·4	2·0	2·0
			Magdalen Gymnasium	663	—	1·8	1·9	1·9	2·0	2·5	2·4	2·0
	1870	Breslau	Frederick Gymnasium*	361	—	1·8	2·0	1·8	2·4	2·2	2·2	1·8
	1867	Breslau	University*	410	—	—	—	—	—	—	—	2·7
Erismann	1870	Petersburg	7 Gymnasia, 1 Progymnasium, 4 German Schools, 1 Girls' School, in all	4358	0·9	1·2	1·2	1·4	1·6	1·8	2·0	
Burgl	1873	Munich	High School, Girls'	179	—	—	—	1·8	2·1	3·7	3·7	
Conrad	1875	Königsberg	3 Gymnasia (Test-Types)	1518	0·8	1·0	0·9	1·0	1·5	1·7	2·2	
			(Ophthalmoscope)		1·0	1·3	1·0	1·3	1·6	1·9	2·7	

* Also $M < 1\ D$

Note to Curve Diagram.



(a) Breslau, Holy Ghost Real School.
(b) Breslau, Zwinger Real School.
(c) Breslau, Elizabeth Gymnasium.
(d) Breslau, Magdalen Gymnasium.
(e) Breslau, Frederick Gymnasium.
(f) Rostock, Gymnasium.
(g) Frankfort on the Main, Gymnasium.
(h) Wiesbaden, Gymnasium.
(i) Vienna, Leopoldstadt Gymnasium.
(k) Königsberg, 3 Gymnasia.
(l) Erlangen, Gymnasium.
(m) Hamburg, Johannes Gymnasium.
(n) Wandsbeck, Gymnasium.
(o) Hamburg, Reform. Real School.
(p) Hamburg, Johannes Real School.
(q) Magdeburg, Cathedral School.
(r) Magdeburg, Convent School.
(s) Zittau, Gymnasium.
(t) ,, Real School.
(u) Dresden, Royal Gymnasium.
(v) Coburg, Gymnasium.
(w) Darmstadt, Gymnasium.
(x) Langenbielau, 5 Village Schools.
(y) Breslau, 20 Elementary Schools.
(z) Average of all 24 Institutions.

As Donders[46] had asserted that he had *never* seen an eye constructed hyperopically become short-sighted, Erismann's statements concerning the prevalence of *H* and its gradual change into *E* and *M* naturally aroused much criticism and doubt. In order to set the question at rest, I had recourse to the decisive method of *examining a whole school with atropine.* A combination of favourable circumstances, occurring in 1877 in Schreiberhau, a village of Silesia, in the Riesengebirge, enabled me to make this experiment;—an experiment which involves, in any case, no injury to the child. Such a permission to atropinise a whole school has never been granted to any oculist before or since.*

I atropinised first all the right eyes of the 240 children and, 14 days later, all the left eyes, since it seemed too venturesome to paralyse the accommodation of both eyes at once. (Homatropine, which dilates the pupil for only a few hours, was not then in existence.) My examination gave[47] the following results: (1) More than 80 per cent. of the village children are apparently emmetropic. (2) Anisometropia, or difference in refracting power between the two eyes, is very rare. (3) Ametropia occurs twice as often among boys as among girls. (4) *M* had not yet shewn itself in 1 per cent. (5) While only 4 eyes were found *M*, facultative-manifest *H* was very common (77 per cent. in the right eye and 64 per cent. in the left). (6) H^m (manifest hyperopia) is rather more frequent among girls than among boys. (7) The number of cases of H^m does *not* decrease

* While these proof sheets were being corrected, I received by letter some information respecting the observations of Dr. Dürr, in Hanover, who examined 414 eyes of school children by means of *homatropine.* This drug had the effect of relaxing the accommodation of *most* of the scholars, after about 43 minutes; but in a few cases the accommodation spasm resisted the homatropine. No inconvenience continued to be felt by the children, when after the examination, the antidote *eserine* was dropped into the eyes. Of the children examined, 79 per cent. experienced an increase of distance of the far point. Thus Dr. Dürr, too, found, by means of homatropine, accommodation-spasm to be an attendant symptom of *M.* The speedy publication of Dr. Dürr's tables is in prospect.

from the 6th to the 13th year (a flat contradiction, then, of the result obtained by Erismann in his examination of *Town* Schools). (8) Every degree of H^m from $^1/_{80}$ to $^1/_{10}$ occurred, H $^1/_{60}$ being the most common; the higher the degree, the rarer. (9) The average degree of H^m was $^1/_{53}$ for the right eye and $^1/_{63}$ for the left. (10) *Every apparently emmetropic eye became hyperopic after the dropping in of atropine;* out of 299 eyes only 4 remained emmetropic on account of the imperfect paralysing of the accommodation. (11) Every degree of H^t (total hyperopia) from $^1/_{80}$ to $^1/_7$ was found, $^1/_{36}$ to $^1/_{20}$ being the most frequent. (12) The average degree of H^t is low ($^1/_{35}$ for the right eye and $^1/_{50}$ for the left). The *latent hyperopia disclosed by atropine* varied from 0 to $^1/_9$, the most frequent amount being $^1/_{50}$ to $^1/_{30}$. In 17 per cent. of the whole number of cases there was no increase of H. (13) No essential difference appeared between boys and girls as to the degrees of H^m and H^t. (14) *Neither H^m nor H^t shewed any decrease in degree according to the age of the child.* (15) Almost all apparently E children have $V > 1$; most have $V = 2$, many have $V = 2^1/_2$, and some of them even have $V = 3$. Not one child in Schreiberhau, when examined with Snellen's table of coloured letters, was found to be colour-blind.

My experiment therefore confirmed Erismann's supposition that *hyperopia is the normal condition of the eye in youth.*

In order to put an end to all arguments against the possibility of proving the first statistical conclusions as to the increase of short sight in schools, it seemed to me to be of the highest importance *to examine again as to their refraction the same children of a school after an interval of a few terms.* I therefore examined[9] the pupils of the Friedrich Gymnasium in Breslau, in May, 1870 and repeated the examination in November, 1871. At

the first examination 174 out of 361 children were found abnormal, namely 35 per cent. *M*, 7 per cent. *H* and 6 per cent. with eye disease. From the seventh to the first class I found the following increase in the number of myopes: 13 per cent., 21, 27, 35, 48, 58 and 60 per cent. Twelve per cent. were found to be $M\,{}^1/_{50}$ to ${}^1/_{36}$, 47 per cent. $M\,{}^1/_{36}$ to ${}^1/_{16}$, 25 per cent. $M\,{}^1/_{15}$ to ${}^1/_{8}$, and 6 per cent. $M > {}^1/_{8}$. After an interval of 18 months 103 *E* and 71 *M* had left the Gymnasium; only 84 previously recorded *E* and 54 previously recorded *M*, in all 138 scholars, could be re-examined. Of the 84 formerly *E* only 70 had remained *E*, while 14 (or 16 per cent.) had become *M*. The degree of *M* acquired in the interval varied from ${}^1/_{50}$ to ${}^1/_{20}$. *Of the 54 previously found to be M, 28 had developed a decidedly higher degree of short sight in the year and a half.* I found not one instance of a decrease in the degree of *M*.

Both the lowest and the highest degrees furnished their contingent to stationary and progressive *M* as follows:

$M\,{}^1/_{50} - {}^1/_{36}$	was progressive	in	30	per cent.	cases.
$M\,{}^1/_{35} - {}^1/_{24}$	,,	,,	38	,,	,,
$M\,{}^1/_{23} - {}^1/_{16}$	,,	,,	69	,,	,,
$M\,{}^1/_{15} - {}^1/_{12}$	,,	,,	100	,,	,,
$M\,{}^1/_{11} - {}^1/_{8}$	,,	,,	43	,,	,,
$M\,{}^1/_{7} - {}^1/_{4}$	,,	,,	66	,,	,,

Thus out of 54 *M*'s examined there were 28 (=52 per cent.) progressive.

The average degree of *M* in all the progressive cases was in the first examination $M = \frac{1}{20{\cdot}6}$; in the second $M = \frac{1}{14{\cdot}6}$; the average increase, therefore, in the short space of a year and a half was $M\,{}^1/_{50}$.

With regard to *V*, it is important to state that all the children found *E* in the first examination and *M* in the second had retained their full *V*; in two cases only of stationary *M* (out of 26) *V* had decreased to ${}^2/_{3}$ and ${}^2/_{5}$ respectively. Among the 28 progressive *M*'s

23 had $V = 1$ a year and a half before; in 4 of them it had now fallen to $^2/_3$ and $^4/_5$. Five progressive M's had in the first examination $V = {}^2/_3$; in none of these was there any decrease. Staphyloma had appeared in 14 of the scholars who had passed from E to M. Among 26 stationary M's the cases of staphyloma had increased from 7 to 14. There were twelve cases of stationary M in which no staphyloma had developed itself. Among 28 progressive M's the first examination shewed 15 cases of staphyloma; now there were 22. Thus 10 per cent. cases were found of *changes in the background of the eye* which had taken place in the space of three half-years.

These results were confirmed by Dr. A. v. Reuss,[15] who repeated the examinations in the Leopoldstadt Gymnasium in Vienna in the years 1874, 1875 and 1876. He had tested with the ophthalmoscope all the short-sighted scholars and all those whose V was < 1; he had also tested with convex glasses for H^l every E and had examined each eye separately. In May, 1872, he found among 409 scholars 35 per cent. E, 41 per cent. M and 20·5 per cent. H; 2 per cent. astigmatic and 0·7 per cent. with eye-disease. The number of M's increased from class to class: 28, 41, 49 and 48 per cent. H decreased from class to class: 30, 27, 14 and 12 per cent. The low degrees of $H\,^1/_{60} - {}^1/_{36}$ were found in 85 per cent. Out of 162 examined with the ophthalmoscope von Reuss was able to shew 41 cases (or 25 per cent.) of accommodation spasm; namely, 16 among $M\,^1/_{60}$ to $^1/_{36}$, 12 among $M\,^1/_{36}$ to $^1/_{24}$, 13 among $M\,^1/_{24}$ to $^1/_{16}$, 11 among $M\,^1/_{16}$ to $^1/_{12}$, 13 among $M\,^1/_{11}$ to $^1/_6$. No increase of the spasm was observed corresponding to the rank of the class. Myopia of different degrees in the two eyes was found in 102 scholars; 54 had one eye E while the other was in 38 instances M and in 16 instances H; 7 had one eye M and the other H.

A year later a second examination was held in the same school, but unfortunately without the ophthalmoscope. Only 211 of the children were present. In 42 per cent. the refraction was the same; in 46 per cent. it was *progressive* and in 12 per cent. *regressive*. In the lower classes more cases were stationary than in the higher. 71 per cent. remained *E*, 19 per cent. had become *M* and 10 per cent. *H*. Of the short-sighted scholars 28 per cent. were stationary, 61 per cent. progressive and 11 per cent. regressive (afflicted, therefore, with accommodation spasm). Owing to the lack of ophthalmoscope and atropine these numbers must be received with caution.

The third examination conducted by von Reuss[25] took place in the year 1875, when 201 scholars were present and the following results were obtained:

Altogether.	After 1 Year.	After 2 Years.	After 3 Years.
Stationary -	42 per cent.	37 per cent.	28 per cent.
Progressive -	47 ,, ,,	50 ,, ,,	61 ,, ,,
Regressive -	10 ,, ,,	11 ,, ,,	10 ,, ,,

	Stationary.	Progressive.	Regressive.
Further, from 1872—1875:	*E* 56	*E* 37	*E* 10
	M 15	*M* 77	*M* 8
	H 12	*H* 72	*H* 16

More precise details of the increase in the separate degrees are given in the original work. Only 12 per cent. of the *M*'s proved to be unchanged after three years. Accommodation spasm was also found, but there was no case of regression with $M > {}^1/_{14}$. In comparing the results obtained by test types and ophthalmoscope v. Reuss found: (1) That in a not large number of eyes the progression is only *apparent*, being caused simply by spasm. Spasm may exist for years without altering the construction of the eye. (2) That in continuous spasm the actual condition of the refraction is altered in a progressive direction and that this is the most usual case. (3) That it is by no means unusual for the

progressive changes to take place without simultaneous accommodation spasm. The origin, therefore, or the increase of *M* is not always to be looked for in a convulsive tension of the ciliary muscle.

With all due respect for the laborious ophthalmoscopic examinations conducted by most of the later writers, who have tested the refraction of all the children concerned, it must be stated that these examinations are by no means infallible. I have often enough seen that even with plane mirrors and in large spaces the accommodation was not wholly relaxed, nay that in some cases the mirror first really brought it into action; this fact has also been acknowledged by v. Reuss and Stilling. These lists of observations are, therefore, not absolutely trustworthy; to make them so, it would be necessary that every individual child examined, and if possible the examiner himself, should be atropinised. For questions of hygienic statistics, reading and lens tests—in the case of school children—will doubtless retain in the future the high value now accorded to them. Conrad[20] also, who examined the whole number of children most carefully with glasses and ophthalmoscope, is of opinion that with the ophthalmoscope one can never be sure that the accommodation muscle is entirely relaxed, but he nevertheless considers that atropine makes an extremely slight difference in the results. On examining 3,036 eyes with reading tests, he found 11 per cent. *H*, 55 per cent. *E* and 32 per cent. *M*: with the ophthalmoscope the percentages were 47 *H*, 29 *E* and 22 *M*. He also agrees with Erismann that *H* slowly passes through *E* into *M*. With the ophthalmoscope he found in the lowest class 70 per cent. *H*, in the highest only 22 per cent.; *E* in the lowest class 25 per cent., in the highest 24 per cent. and in the intermediate classes 30 to 35 per cent.; while according to the ophthalmoscope *M* increased from 4 to 51 per cent. and according to the reading

test from 11 to 62 per cent., so that about 10 per cent. were cases of accommodation spasm.

We find that repeated examinations of the same scholars were made afterwards by Ott[48] for Lucerne, by Netoliczka[42] for Graz and by Florschütz[43] for Coburg The investigations of this last are of the highest interest, because they establish *a decrease among the number of M's in the newly-built "school-palaces."* Thus in the municipal schools, in the year 1874, 12 and 14 per cent. of the scholars were *M*, and in 1877 there were only 4 and 7 per cent. Among all the 2,323 examined in 1874 there were 21 per cent. *M*, and in 1877 only 15 per cent.

Very valuable also are the most recent contribution to our knowledge of the subject, those, namely, made by Erismann* in St. Petersburg, which I did not see till after the completion of this work.

In the year 1876 Erismann was able to test for the second time the refraction of 350 eyes, examined by himself in 1870, six years earlier. Only 23 of these eyes were found to be in the same refractive condition. In 67 per cent. the refraction had increased, thus:

H had decreased in 7 per cent. of the eyes.
H had passed into *E* in 8 ,, ,,
H ,, *M* in 13 , ,,
E ,, *M* in 16 ,, ,,
M had increased in 25 ,, ,,

The refraction had decreased in 9 per cent., thus:

H had increased in 3 per cent of the eyes.
E had passed into *H* in 5 ,, ,,
M had decreased in 0·5 ,, ,,
M had passed into *E* in 0·5 ,, ,,

It is therefore beyond doubt that a change of refraction takes place in children's eyes *during school-life* and in the very great majority of cases this change is

* Handbuck d. Hygiene u. der Gewerbekrankheiten, herausg. v. Pettenkofer u. Zeimssen. II. 2. Hygiene der Schule, bearbeitet v. Dr. Erismann. p. 30. 1882.

progressive, that is, the axis of the eye becomes longer.

"The relatively few cases of *regressive* refraction may be accounted for," says Erismann, "almost without exception by the fact that, owing to a high tension of the accommodation, hyperopia, previously latent, becomes manifest. It is seldom found that the eye of a scholar, even when it is not yet really myopic, but has only an apparent myopia owing to accommodation spasm, returns afterwards to its normal condition. The accommodation spasm almost invariably developes those permanent changes which characterise the myopically constructed eyeball. By way of example, I will only mention a few cases observed by me of changes of refraction in the eyes of school children:

$H\,^1/_{36}$ was changed into $M\,^1/_{21}$,
$H\,^1/_{60}$,, ,, ,, $M\,^1/_{20}$,
$M\,^1/_{14}$,, ,, ,, $M\,^1/_{6}$,
$M\,^1/_{20}$,, ,, ,, $M\,^1/_{7}$,
$M\,^1/_{50}$,, ,, ,, $M\,^1/_{10}$;

and it is an important fact that in these cases not unfrequently there was proved a decrease of the power of sight

Again, it may be a matter of general interest that in the only examination which has hitherto been held in a Kindergarten (a very careful examination under Koppe[23] in Dorpat) *not one single case of myopia* was discovered, while there were 98 per cent. *H* and 2 per cent. *E*.

By way of appendix, I may mention the results found by examining the *eyes of students*. In the years 1861-1865 Dr. Gärtner examined 138 students of the Evangelic-Theological Foundation in Tübingen and found the percentage of *M* to be 81. On making a summary of the years 1861 to 1879 (after a second examination), he found that of 634 Evangelical Divinity Students 79 per cent. were *M*.

Donders had already uttered these apt words: "It would be of the highest value if we could obtain accurate

statistics concerning the amount of ametropia existing at a given time in a special class of persons, for instance, the whole of the students of a university, in order to be able to compare these statistics with the results of repeated examinations at later dates. Now if it were shewn by this means—and I have little doubt that such would be the case—that short sight among the educated classes is progressive, this would be a very grave symptom, and we should be bound seriously to consider how this progress of short-sight could be arrested."

Such a table of statistics I[50] tried to begin at Breslau in the year 1867, but without success, since I was not able to induce all the students to submit to examination. Out of 964 students only 410 presented themselves. Among these 60 per cent. were *M*, distributed as follows:

Students of	Catholic Divinity	53	per	cent.
„ „	Law	55	„	„
„ „	Medicine	56	„	„
„ „	Evangelical Divinity	67	„	„
„ „	Philosophy	68	„	„

In the year 1880 I again tested[51] 108 medical students, and found 57 per cent. *M; before* the University examination, known as Examen Physicum 52 per cent., and *after* it 64 per cent. *M*. Seggel[35] proved that out of 284 volunteers and cadets who had left the gymnasium there were 58 per cent. *M*. Collard[52] examined the eyes of the students in Utrecht in the winter of 1880, 410 out of the 550 students being present. Of these 820 eyes 27 per cent. were *M*, in the following proportions:

Students of	Divinity	23	per	cent.
„ „	Medicine	26	„	„
„ „	Law	29	„	„
„ „	Natural Science	32	„	„
„ „	Pharmacy	31	„	„
„ „	Philosophy	42	„	„

Collard did not find more short-sighted students among the older than among the younger men; on the contrary, there was a decrease thus: From the 18th to the 20th year, 30 per cent.; from the 21st to the 23rd, 28 per cent., from the 24th to 27th, 27 per cent. But then, the oldest students are by no means always the most diligent.

CHAPTER NINTH.

Myopia among School Children of Different Nations.

It has often been affirmed that the German schools are the nurseries of short sight; but it can be seen, even from Table I. in Chapter VIII., that there is no lack of short-sighted children in other countries.

According to Maklakoff[11] the percentage of *M* is lowest among the Georgians and Armenians of the Caucasus; but in Woinow's German report numbers are not given. Exactly the opposite opinion is held by Reich[37], who found in the four schools examined by him at Tiflis, and containing 1,258 scholars, more *M*'s among Georgians and Armenians than among Russians (see Table I.). For instance, the percentages of *M* in the gymnasium were thus: Armenians 38 per cent., Georgians 45 per cent., Russians 30 per cent. He also found, especially among the Armenians, the higher degrees of *M*, and a rapid rise of the percentage from class to class. He was struck, too, by the large and prominent eyes of the Armenians and Georgians. In the lowest classes of the gymnasium at Tifiis Reich found only 12 per cent. *M*, in the highest classes 71 per cent.; on the other hand, *V* was $^9/_6$ in 52 per cent. of the scholars. Dor's[19] statement, "the further south, the greater number of normal eyes," Reich considers open to serious question and he quotes with emphasis Mannhardt as pointing out for special notice the national tendency to short sight among the Italians.

In England up to the present time* only one examination has been held. In the year 1880, Dr. Priestley

* The date on Dr. Cohn's title-page is 1883. [Eng. Editor.]

Smith[53] examined 1636 school children and found 5 per cent. *M*, while among 357 students of Training Colleges he found 20 per cent.

In France investigations were set on foot in 1874 at Lyon by Gayat[54], who examined nearly 600 scholars taken "au hasard, ou sur la demande du maître." To estimate the *M*-number, obtained in this manner, as 3 per cent. of the total number of scholars is altogether inadmissible. Dor at first relied on Gayat's statistics and concluded that *M* prevailed far less in France than in Germany; but he[36] afterwards examined for himself a lyceum in Lyon and there found 23·4 per cent. *M* (a percentage like that in German gymnasia). Nicati[40] examined in Marseille 3434 scholars by means of spectacles and ophthalmoscope and found in the Jewish primary schools 15 and 10 per cent. *M*, against 8 and 7 per cent. in the Christian primary schools. He considered this to be the best of evidence for the heredity of *M*, since the Jewish scholars were children and grandchildren of tradesmen who could read and write, while the Christian scholars came of a stock of labourers, mechanics, and peasants, and were the first generation in their families to enjoy school education.

Pflüger[55], on examining 529 Swiss teachers from 20 to 25 years of age, found that there was more short sight among the Germans than among the French. 154 French Swiss had 14·3 per cent. *M* and 357 German Swiss 24·3 per cent.

	Italian Swiss.	German Swiss.	Total.
$M > 1/24$	4·5 per cent.	12·0 per cent.	10·5 per cent.
$M > 1/24$ and $1/12$	59·0 ,,	40·0 ,,	44·0 ,,
$M > 1/12$ and $1/8$	27·5 ,,	35·5 ,,	32·0 ,,
$M > 1/8$ and $1/6$	9·0 ,,	10·0 ,,	10·0 ,,
$M > 1/6$	0·0 ,,	4·5 ,,	3·5 ,,

Emmert[27] examined 4 Swiss watchmakers' schools, and found 71 per cent. *H*, 15 per cent. *E* and 14 per

cent. *M*. Insufficiency of the internal rectus was very prevalent, the percentage being 54. In the schools of those places, too, where watchmaking was carried on there was 22 per cent. insufficiency against 4 per cent. in other towns. Emmert is of opinion that watchmaking is very apt to cause muscular irregularity through the use of the magnifying glass with a single eye and that the tendency to this muscular irregularity is especially apt to become hereditary.

In America Callan[21] examined 457 negro scholars. They were from 5 to 19 years of age, and attended two schools in New York. Only 2·6 per cent. were *M*; 3 per cent. in the higher school, and only 1·2 per cent. in the lower. There was no case of short sight below the age of 10 years: the higher degrees $^1/_8$—$^1/_4$ were only found among children above 14 years of age. No short sight existed in the primary departments of these schools; the grammar departments had 8·2 per cent. in the higher and 1·6 in the lower school respectively. With spectacles Callan found only 67 per cent. *H*, but with the ophthalmoscope, *after he had dropped atropine into his own eyes* (certainly as desirable for the examination as unpleasant for the examiner) he found 90 per cent. *H*. Loring[26] and Derby also examined 2265 eyes of school children in New York, and report the same increase of *M* from class to class as that noticed in Germany. It is interesting to learn that among the children of German parents these examiners found 24 per cent. *M*, among children of American parents only 20 per cent. and among children of Irish parents only 15 per cent. The total *M*-number, however, was smaller than in Germany, being 7 per cent. in the Primary Schools, 12 per cent. in the District Schools, and 27 per cent. in the Normal Schools.

An examination organized by Agnew[31], and carried out by several medical men was held in various higher and

lower schools of New York, Cincinnati, and Brooklyn: 1,479 scholars were examined with the ophthalmoscope and glasses and the following results were obtained:—

Citizens' Schools, Cincinnati	-	10 per cent. *M*
Middle „ „	-	14 „ „ „
Normal Schools „	-	16 „ „ „
Lowest Class, New York	-	29 „ „ „
Freshman Class „ „	-	40 „ „ „
Sophomore „ „ „	-	35 „ „ „
Junior „ „ „	-	53 „ „ „
Senior „ „ „	-	37 „ „ „
Academic Department, Brooklyn		10 „ „ „
Collegiate „ „		28 „ „ „

Hasket Derby[33] found in Amherst College, Boston, 28 per cent. *M*, in Harvard 29. Half of the short-sighted ones had become more short-sighted by the following year. After four years he repeated the examination and saw that 10 per cent. of *E* had changed into *M* and that 21 per cent. of *M* had increased in degree. In 1875 there were 51 per cent. *E*, 5 per cent. *H* and 45 per cent. *M**. In 1879 there were 36 per cent. *E*, 13 per cent. *H* and 51 per cent. *M*.

We will add in conclusion that Collard[52] found only 27 per cent. *M* among 790 eyes of Dutch students, against 40 per cent. among 30 eyes of German students in Utrecht.

From all the facts in our possession we can infer with certainty only thus much: that in other countries too few examinations have been held for a statistical comparison with Germany, but that *in the whole civilised world the number of short-sighted scholars increases with the requirements of the school and with the rank of the class.*

* While this proof-sheet was under revision, I received an interesting report of the first examinations held in S. America. The author, Mr. P. F. Roberts, tested 6,163 scholars and found only 260 cases (=4·2 per cent.) *M*. Enviable people!
Examen de la Vision practicado en las escuelas publicas de la ciudad de Buenos Aires, capital de la Republica Argentina, Buenos Aires, 1882.

CHAPTER TENTH.

INFLUENCE OF HEREDITY ON THE SHORT SIGHT OF SCHOOL CHILDREN.

short sight

As the fact of the enormous increase of *M* during the time spent at school could no longer be denied, attempts have been made to explain the origin of this "disease of civilization" and champions have not been lacking for the view which entirely acquits the school and gives the blame exclusively to heredity or exclusively to home occupations.

Donders[46] says: "My experience shows that *M* is almost always inherited and, when inherited, exists in the child at least in the form of a predisposing tendency; but that it can nevertheless, without an original disposition, be developed in the normal eye by over-exerting the accommodation." Donders adds no statistics of percentage.

Now if we meant to arrive at any definite conclusions concerning this question, we should be compelled to examine personally *the parents of the school-children as well as the children themselves.* That, as yet, has nowhere been done. In examining short-sighted children I[6] have asked them the following questions:—(1) Does your father or mother wear spectacles or an eye-glass? (2) Do they use them out of doors? at home? for writing or sewing? (3) Do *you* see better or worse with your parents' glasses, near to you or far off? (4) If your parents do not wear glasses, do they complain of not being able to see well at a distance? (5) [In the higher classes.] Do your parents wear concave or convex glasses?—By further questions put to the parents I obtained much additional information. In many cases, indeed, father and mother

had long been dead; moreover, none of the instances appear in which parents were *M*, but in so slight a degree as to cause no complaint or need of spectacles.

On the whole I learned in this way that out of the 1,004 *M* scholars that I discovered only 28 (=2·7 per cent. of all *M* and 0·2 per cent. of all the scholars) had a short-sighted father or mother. In 11 cases the mother was *M* and in 17 cases the father. To judge from this very small number of instances, the *M* seems to be transmitted from mother to daughter and from father to son. In the village schools and higher girls' schools, the children gave no evidence that any parent was *M*. I attach no great importance to these numbers, but they appear to me to shew that the number of short-sighted children with short-sighted parents is by no means so great as is commonly supposed. I am confirmed in this belief by the fact that in the course of years I have in my private practice examined a very great number of myopic children brought to me by parents who were not short-sighted.

Erismann[10], too, has taken the prudent step of collecting facts respecting the *M* of parents. He thus found *M* fathers more numerous than *M* mothers. The father was *M* in 5 per cent. of all cases and in 16 per cent. of all *M*. The mother was *M* in 39 per cent. of all cases and in 12 per cent. of all *M*. Both parents were *M* in 10 per cent. of all cases and in 3 per cent. of all *M*. Thus, in all, the short sight was inherited in 30 per cent. of all *M* examined.

He heard of myopic brothers and sisters in 24 per cent. of the *M* cases and of myopic brothers and sisters without myopic parents in 16 per cent. of the *M* cases.

Among the myopic girls the percentage of *M* mothers was rather higher than among the *M* boys, but both among *M* boys and *M* girls the father was *M* in more than half the cases; among the *M* boys 57 per cent.

of the fathers were *M* against 42 per cent. of the mothers; and among the girls 52 per cent. of the fathers against 48 per cent. of the mothers.

Erismann further found among children of *M* parents no atrophy of the choroid in 3 per cent. of short-sighted parents against 5 per cent. of all the short-sighted children; a moderate degree of atrophy of the choroid in 67 per cent. of the children of short-sighted parents against 71 per cent. of all the short-sighted children; a high degree of atrophy in 29 per cent. of the children of short-sighted parents against 24 per cent. of all the short-sighted children. He considers that there is nothing surprising in the preponderance of cases of great choroidal change among scholars with *M* parents, since "the inherited structural tendency of any organ necessarily becomes perceptible in the later development of the organ in such wise that the abnormal tendency is more strongly declared than it is when it has been contracted for the first time during the lifetime of the individual. In this manner we should have the by no means cheerful prospect *that, a few generations hence, all Europeans, or at least all those living in towns, will be short-sighted.*"

Nagel[57] does not set much value upon Erismann's statistics as to the heredity of *M* and rightly asks "Where are the parallel lists for comparison? Heredity will not surely be taken for granted in the 30 per cent. above mentioned? If practical conclusions are to be obtained, closer investigations seem necessary and, especially, more definite questions must be answered. For instance, do we find more short sight in respect of number of cases and of degree, more choroidal changes, more insufficiency among 100 children of short-sighted parents than among 100 similar children of not short-sighted parents?"

As conclusive evidence I should only accept statistics based on an examination of some thousands of children *and of their parents* (and, where possible, of their

grandparents). Twelve years ago I endeavoured to contribute towards the solution of this question by applying for permission to examine, at the opening of a gymnasium in a small provincial town, the candidates for admission and the parents who brought them. Unfortunately, however, I was unable to obtain the authoritative permission without which the project cannot be carried out.

In future it is to be hoped that the authorities will themselves promote investigations of this kind and then if—as is not at all improbable—the heredity of short sight or the hereditary tendency to short sight should be *positively* demonstrated, we should be doubly bound to make every exertion to prevent the increase of *M.*

The reports already published are based on too small numbers. Dor[19], for example, found in the real school at Bern in 1874 among 42 *M* 25 (=59 per cent.) whose myopia was inherited.

Scheiding[22] in Erlangen found, as I did, myopia transmitted generally from mother to daughter and from father to son. But, as Nagel aptly observes, it is a very venturous assertion on Scheiding's part that, having regard to their *H* and *E* brothers and sisters, the *M* of 76 per cent. of the *M* scholars must be considered as acquired, while in the remaining 24 per cent., having regard to the *M* of the brothers and sisters, it must be safe to assume an hereditary predisposition.

Nagel's hint respecting parallel lists was taken by Pflüger[24], who found in the public schools of Lucerne: (1) In 100 families with 449 children and no hereditary predisposition scarcely 8 per cent. *M* children. (2) In 100 families with 395 children and hereditary predisposition 19 per cent. *M.* (3) In real schools and gymnasia, in 85 families with 280 children *without* hereditary predisposition 17 per cent. *M.* (4) In real schools and gymnasia, in 55 families with hereditary predisposition 26 per cent. *M.* On the whole, therefore, with

short-sighted parents, short-sighted children were more numerous. Pflüger does not assume that in 31 per cent. more cases those scholars in gymnasia and real schools, who belong to families in which short-sight is hereditary, must *inevitably* become *M*, but that these 31 per cent., at least in part, represent a *greater predisposition to M* which with injurious circumstances is developed but with favourable circumstances may remain latent. In the lower and higher schools the difference for the worse in the *M* families remained about the same, namely, 10 per cent. "This number" (10 per cent.) says Pflüger, "gives us an approximate idea of the frequency of hereditary myopia as far as it asserts itself as an unpreventible and incurable structural defect; and, if anything speaks for the frequency at the present day of acquired short sight, it is this number 10 per cent. This investigation affords one proof more of the great importance attaching to the influence of outward circumstances, especially the school, upon the development of short sight."

Further, the opinions of oculists on this question of the heredity of *M* are widely divergent. Von Arlt[58], who deserves the chief credit of demonstrating the anatomical basis of *M*, says very justly: "Short sight itself cannot be looked upon as hereditary, but only the *tendency* to short-sight. It is not proved that the eye developes into the elongated structure by reason of a structural impulse existing within it *ab ovo*. The anatomical changes found in the *M* eye still possessing normal *V* are against such an assumption." As a proof that *M* may be acquired without any inherited tendency v. Arlt instances his own case. He belongs to a family in which there never was any short sight. When a child he was himself *E*, and he did not become *M* $^1/_{24}$ until he had studied hard from his 13th to his 16th year.

Loring[59] considers the heredity, although not statistically proved, to be beyond all doubt, but he thinks that its

influence is over-rated. As one of the essential "changes of the conditions of existence" which affects the mass of people and is capable of altering the type of the eye, he mentions compulsory school attendance.

Nicati[40] regards his results above referred to in the Jewish Schools of Marseille (page 85) as evidence of the heredity of *M*. Kotelmann[28], too, attaches great importance to heredity. In 24 cases he found both parents short-sighted, and in 20 of these cases the *M* was transmitted to the sons. In 112 cases the father only was *M*, in 50 per cent. *M* was transmitted to the sons. In 43 cases the mother only was *M*, and in 25 her sons were *M*.

Javal[60], on the contrary, lays very little stress on heredity. He thinks that American children of German parents are more short-sighted than children of other descent not because of heredity, but because Germans make their children work a great deal out of school, and often at night by a bad light. That may easily be, but when Javal asserts that the increase of the number of the *M* in the higher classes is no proof of the increase of myopia, he stands quite alone in this opinion. He believes that only the short-sighted children stay at school and that the non-myopic children in the higher classes leave; he also considers it an exception to find *M* developing itself after 12 years of age. Whereon Nagel justly observes: "Two bold assertions!"

From all the opinions which experts have communicated to us only thus much follows: *that the question of the heredity of M is not yet decided; that the transmission of the tendency to M is at least highly probable, but that in very many cases, without any hereditary predisposition, M is developed by other causes.*

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CHAPTER ELEVENTH.

School Desks.

Whatever opinion we may hold about hereditary tendency, we cannot be blind to the fact that almost all children come to the lowest class of our schools with perfectly sound eyesight, while from class to class there is an increase in the number and in the degree of cases of short sight. So far back as eighteen years ago I sought an explanation of this fact in various *local* circumstances of school work. H. Weber[44] in his last and beautiful treatise comes to the conclusion that "the earliest and principal influences for the development and spread of short sight are to be found in school work. A most accurate analysis of all the concurrent circumstances is necessary in order to determine where the chief causes of injury are lurking, whether in the length of occupation or in the kind of occupation, and if the latter, which kind of occupation is to blame?"

Many years ago, the orthopædic doctors had pointed out the *school desk* as the thing above all others tending to originate spinal curvature. The American writer Barnard, in his great work on School Architecture (1860), upheld the principle that during writing the form ought to be close up to the desk. Schreber[64], Schraube[103], Passavant[104], Freygang[105], Fink[106], and Zwez[66] also insisted on the importance, for the scholars' normal growth, of well-constructed desks; but they did not see wherein lay the very chief defect of the old school desks.

The question was dealt with from a wholly new point of view by Dr. Fahrner of Zürich who in his small but classical book, "The Child and the School Desk"

(1863) pointed out *why* the children could not possibly sit upright for long at a time at the old desks, why they were forced to fall forward and why a thorough reform in the make of school desks was necessary.

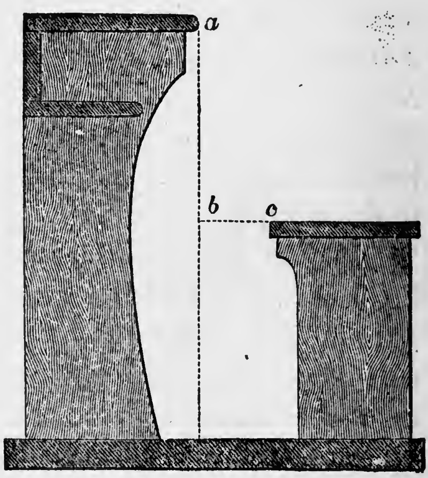
No one before or since Fahrner has more accurately described the mechanism of the collapse of the child's posture when writing; and therefore it seems best to quote from this investigator, who died all too soon, the description of this important process.

"Before the writing begins," says Fahrner (p. 17), "the children sit perfectly upright with both shoulder-blades thrown back equally (that is, the shoulders are parallel to the edge of the desk), and the slate or copy-book is so placed before the child that its left margin lies a little to the left of the middle of the body. *But as soon as the writing begins all the children move their heads slightly forward and towards the left,* without perceptibly altering their attitude in any other way. *Soon, however, head after head drops down with a rapid jerk,* so that the neck now forms a considerable angle with the rest of the spinal column. In a short time *the upper part of the back also collapses,* so as to hang from the shoulder-blades, which in their turn are supported by the upper arm. *From this moment the scholars are divided into two groups, according to the part of the slate at which they happen to be writing.* Those who are writing on the upper half of the slate or at the beginning of a line are able to support themselves on *both elbows,* and they let their chest sink straight forward against the table. The back in this way becomes curved simply; it becomes what I call a *round back.* The eyes are from 3 to 4 inches distant from the desk and look straight down upon the writing. For points of support the child uses the front of the chest, the left elbow (which is constantly moved outward till it is a long way from the body) and the right fore-arm anywhere between the

elbow and the wrist. But those scholars, who at the critical moment are writing at the end of a line or near the bottom of the slate, cannot any longer support themselves on the right elbow, because it too much overhangs the table and is too far from the body. They are therefore forced to lean on the left elbow alone and, in so doing, not only to bend the spinal column, but to twist it on its axis towards the right. The position is that of the *skewed back.* The points of support are the left side of the chest and the left elbow, which lies very much to the left of the body and forward from the body; the head is bent towards the left shoulder; the right arm, with its shoulder-blade standing out like a wing, rests on the desk anywhere between the elbow and the wrist; the eyes, now frequently only from 2—3 inches distant from the writing, are rolled considerably towards the right and almost squint over the paper.

"Exceptionally, a child pushes the copy-book aslant, twists the spinal column towards the left, and leans upon the right arm. In this case the left shoulder-blade stands out like a wing and reminds us of the rare instances in which we find a girl, whose back is twisted, having the left shoulder higher than the right."

Fig. XXVII.

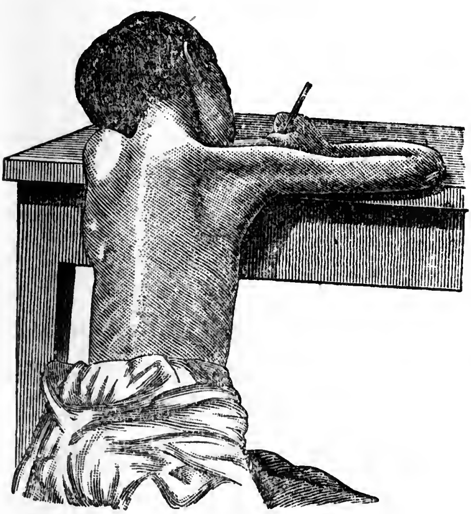


Accurate pictures of the bad attitudes at the old-fashioned school desks (Fig. XXVII.) were afterwards given by Frey (see Fig. XXIX.) and Baginsky (see Fig. XXVIII.)

Of course such an excellent observer as Fahrner could not fail to perceive in these phenomena the

working of a fixed physical law which the children were compelled to obey, and that this law was the law of *gravitation.* Fahrner decided very rightly that the first movement by which the child leaves the normal attitude is a reaching of the head forward to the left and that this apparently unimportant movement is the root of all the evil. After the experiences of many years I cannot do otherwise than entirely agree with him in this opinion. Unimportant as this slight movement appears, it inevitably causes the whole subsequent ruin of attitude.

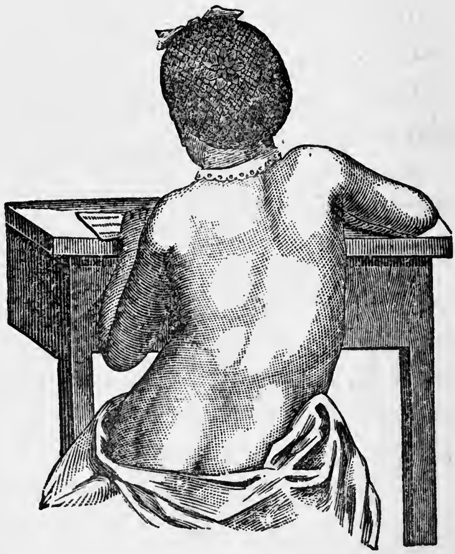
FIG. XXVIII.



"In the normal position," says Fahrner, "the head has its centre of gravity resting upon the bony framework of the spine and is supported by it, so that the muscles of the neck have nothing to do but to balance the head. *That slight stoop forward, however, is enough to push this centre of gravity over the front edge of the spinal column.* The *muscles of the neck* must now hold up the head if it is not to drop downward. The work thus laid upon them is considerable. (The best way of appreciating muscular work is to hold out one arm horizontally for some time instead of letting it quietly hang down.) The muscles of the neck are accordingly soon tired out, their tension is relaxed and the work now falls upon the *muscles of the back.* These in their turn are soon tired out and the child is then forced to lean on other points of support. He tries first one or

both elbows. The elbows support the upper arm, the upper arm supports the shoulder blades and the body hangs upon the shoulder blades until they also give way and the chest must needs find a stay and support at the edge of the desk."

Fig. XXIX.



This inevitable necessity, by which the body hangs upon the shoulders instead of the shoulders' hanging upon the body, leads to that further collapse of attitude in consequence of which the head presently drops down towards the writing and the eyes are distant from the writing only 3—4 inches. Since *the first slight reaching forward of the head* is the cause of all the mischief, it must be prevented at any cost. As the chief causes of this reaching forward Fahrner points out the positive *horizontal distance* between desk and form, and the false vertical distance (the *difference*) between them. (See below.)

Fahrner's counsels were upheld from the very first by Guillaume[107] in Neuchatel, and Parow[108] in Berlin. In spite of this the efforts of these men, even so lately as 1865, met with the greatest opposition. It was urged everywhere, and with some reason, that if the desks were the cause of spinal curvatures, the number of cases of crooked spine ought to be much greater than was shewn by statistics.

The writers above quoted had certainly touched on the importance of a good attitude with reference to eyesight, but throughout they kept too exclusively to the *orthopædic* point of view.

When in 1865 I had studied Fahrner's admirable work and had begun my examinations of the eyes of the Breslau school-children, the question pressed itself upon me: "How far may the old desks in our schools be answerable for the origin and development of short sight?"

To obtain an answer to this question, I[6] first of all measured the height of 10,060 children in the 166 classes examined. I then measured the desks with reference to desk-height (back and front), desk-width, form-height and form-width, difference and distance between desk and form, between form and book-rest and between form and foot-board; height of next desk above form, distance of next desk from desk's front edge, width of book-rest, length of form, width of foot-board, space allowed for each child to sit, &c. I thus found that these old desks were *opposed to every reasonable hygienic requirement*, and were set up quite arbitrarily and without any reference to the height of the children in the classes. Pupils 3 feet 6 inches and 5 feet 2 inches in height sat at the same desk. (I am sorry to say that this occurs even to this day in Breslau!)

But, apart from this fundamental error, I found that the scholars, even when the desk was suited to their height, *were forced* by the old forms *to stoop forward and bring the eye very close to the writing.* That is just how *M* can be produced and increased. (See chapter VII.)

The points which are of main importance in school desks are four: The Difference, the Distance, the Form-height and the Desk-slope.

(1) The *Difference,* that is, the vertical distance between desk and form. The higher the desk-surface, the nearer it is to the eye of a straight-sitting child. Thus, the greater the difference, the more the child will have to exert his accommodation. Now the writing ought to be from 14 to 18 inches [35—45 cm.] from the eye, for that is about the distance of a child's eye from

the elbow when hanging straight down and the text of the school books should be easily legible at that distance. If, however, the difference is great, so that the elbows have to be considerably raised in writing, the shoulders will not hang from the body, but the body from the shoulders, and the writing hand will be too near the eye. The distance between the upper arm when hanging straight down and the seat-bones is, on an average, $^{1}/_{8}$ of the height of the whole body. As, then, the elbow in writing is moved not only forward but also slightly upward, it is necessary, in order to obtain the proper difference, to add from 1·6 to 2·4 inches [4—6 cm.] to $^{1}/_{8}$ of the height of the body. With girls it is necessary to add a few centimeters more on account of their thicker under-clothing, so that in their case the difference is about $^{1}/_{7}$ of their height. Now in the old desks, the difference is too great by about from 3 to 8 inches [8—20 cm.]

(2) An exceedingly important correlative of the difference is the horizontal *Distance* between desk and form. In right arrangement of Distance lies the kernel of school-desk reform. The greater the Distance the more the body will have to fall forward ~~of~~ from the form in order that the arms may reach the paper; and the more will the head be obliged to drop and to get near the writing. Thus, whenever we intend to sit upright at a table for a considerable time, we instinctively push the chair so far under the table that the table's edge is vertically over the chair's edge or, if possible, overhangs it by an inch. *For the upright position of the head, therefore, the Distance must be nil or, still better, negative.* Now in the old desks the distance varied between 3 and 6 inches; it was never nil or negative. Fahrner required a distance nil. Parow also said quite rightly: "In writing, the form and desk should be so near together that the edge of the desk almost touches

the child as he sits upright before it." Buchner[109], accordingly required 2 inches [5 cm.] *negative* distance, and Hermann[110] 2·4 to 2·8 inches [6 to 7 cm.] I once proposed a minus distance of 1 inch; but after further observations I think that the upright position is sustained still longer when the thigh is supported still further towards the knee and therefore I agree with Buchner, who requires a minus distance of 2 inches.

Let no one think that an inch is no great matter. *Here every inch is of consequence. No physician has ever opposed the requirement of nil or minus distance,* although the school desk question has been keenly discussed for the last 17 years.

The opposition has come solely from *individual teachers,* who set up this strange plea: "A positive distance of 3 inches does no harm for, in order to counteract it, the children have only to *slide forward on to the edge of the form.*"

But the necessity of a nil or minus distance is made evident beyond contradiction by the excellent physical investigation of the conditions for an upright sitting posture published by Professor Hermann Meyer in Virchow's Archives. This work of Meyer is well popularised in Baginsky's thorough Handbook of School Hygiene. In what follows, the most important points only of Meyer's theory will be touched upon.

At the lower part of the pelvis are the two seat-bones, or lowest parts of the great hip-bones. They are curved like a bow and rock easily. A line drawn through these two seat-bones may be called the "seat-bones line." The centre of gravity of the human body is situated in front of the 10th chest vertebra; a line drawn perpendicularly from that place to the ground is the *line of gravity.* Now it is only when the line of gravity falls exactly upon the seat-bones line that the body can remain at rest in a sitting posture. The slightest movement of

the trunk that displaces the centre of gravity, and therefore also the *line* of gravity, must bring the line of gravity either before or behind the seat-bones line, and then a third point must be sought for which will secure equilibrium in a sitting posture in spite of the instability of the seat-bones. This third point may be situated either before or behind the seat-bones line. We must therefore distinguish between a forward and a backward sitting posture. In the *forward* sitting posture the third point of support is furnished by the *front edge of the form.* The line of gravity may now fall on any part of that surface which is determined by the seat-bones and the front edge of the form; the nearer, however, it approaches to the latter, the more easily is the equilibrium disturbed. A quiet sitting posture, therefore, will only be possible when the surface of the form on which the thighs rest is very *large*; things are best when this surface extends forward as far as the knees. If, moreover, the knees being bent at a right angle, the feet are planted firm and flat on the floor, their resting places form auxiliary surfaces of support.

No one, however, can remain in the forward sitting posture for any length of time, because the trunk is not immovably fixed in the hip joint but is joined movably to the thighs. The attitude, therefore, is only maintained by very complicated work of the pelvis muscles. These muscles grow fatigued and the trunk, obeying the law of gravity, would *fall forward* if the chest or the arms did not support it by leaning against the table. When we prop ourselves up with our arms, we in a manner catch the body as it falls forward.

In the *backward* sitting posture, in which the line of gravity falls *behind* the seat-bones line, the third point of support, firmly connected with the seat bones, is found in the end of the coccyx, the pelvis being now inclined backward. This point does not need to be determined,

but is an immovable datum. But as the body, with this backward inclination of the pelvis, would have to fall far backward, its fall must be arrested by the back-rest. The lower down the back-rest is applied, the more upright is the position of the pelvis and the trunk. Applied at the height of the last vertebra the back-rest allows the best upright sitting posture.

In writing, the head is slightly bent forward on its horizontal axis, the arms are stretched forward and somewhat upward, and the body curved slightly forward; thereby the centre of gravity is moved forward and the line of gravity brought in front of the seat-bones line. Any arrangement, therefore, which brings the centre of gravity further back will help the child to sit upright.

Now, on the contrary, the more we allow the child to slide forward on to the edge of the form, the more we bring the centre of gravity forward; and the forces which cause the body and head to stoop forward are called more and more into activity with every inch of plus distance because, with plus distance, the thighs are not enough supported.

In every case of plus distance, as is proved by the edges, quite worn away, of old forms, the child's instinctive sliding forward brings about a posture not of sitting but of perching.

This perching posture must at all costs be prevented, as it soon leads to the head's falling forward. The extra four or five inches of thigh, however, supported with minus distance as compared with three inches plus distance, are a powerful aid to longer endurance in an upright writing position.

School-councillor Bock* has proposed a *perching* form with three inches plus distance. Under the name of "New Berlin Form" this old and faulty perching form,

* Volksschulfreund, 1868, No. 13. This "new and serviceable School Desk" was also recommended in Stiehl's Prussian School Authorities' Central Paper, 1868, p. 486.

with which the children stand badly and sit wrong, has been introduced, I am sorry to say, during the last ten years more and more into all new schools of Breslau*, although all scientific treatises and all medical experts condemn every plus distance as injurious to health.

† The recent reports of specialists in Strassburg[118] and Darmstadt[44], which have received the sanction of the Government authorities in Alsace and Hesse, expressly forbid any positive distance, as indeed positive distance has long been forbidden in Switzerland. "This one fault alone," says the Strassburg Commission, "is enough to condemn the old school desks, and to make them the more hurtful, the younger the children are who are compelled to sit in them. So much has been said of late years about the evil effects of positive distance that we need not dwell long upon this point. It forces the child, when writing, to support the upper part of his body with his arms, to bring the chest far forward and to bend the head downward too much. In this way it brings the eye improperly near the paper and thus creates short sight artificially. Moreover it gives the child a kind of invitation to twist the spine sideways.

* There has been no lack of energetic public protests on my part.

† While these pages were being printed, Professor Esmarch, of Kiel, Medical Privy Councillor, sent me a paper which had been distributed in the surgical hospital among parents of children of crooked growth. It is entitled "Instruction about the Sitting of School Children." It contains a complete vindication of the principles above described and is so admirable in its classic brevity that this "instruction" deserves the widest circulation. It says "School children become *crooked* and *short-sighted* by *crooked sitting* on bad (old-fashioned) school forms. They sit crooked when the form is too far off the desk, is too low for the desk and has no proper back-rest. The school form, therefore, is always injurious except when the child cannot help sitting upright upon it in reading and writing, and can so sit up for a considerable time without growing tired. To effect this: (1) The form-seat must be as far above the footboard as the child's leg is long, measured from the bend of the knee to the sole; (2) The form-seat must be as wide as the thigh is long, measured from the knee to the back; (3) The rounded fore-edge of the form-seat must be from $^4/_5$ to $1^1/_5$ inches (2—3 centimeters) further forward than the desk's inner edge; (4) The seat must be high enough for the child to be able easily to place his forearms on the desk in writing, *without* raising his shoulders or bending down his head and back; (5) The lower part of the back must be sufficiently supported in reading (cross back-rest). As these proportions vary with the growth of the children, the seats ought to be readjusted by taking fresh measurements at least every half-year.

With girls especially, slight degrees of spinal curvature (so called 'high shoulders'), due to this cause, are not uncommon." To these long-verified reasons the Strassburg Report adds a fresh argument. At page 33 we find "*The injurious influence of positive horizontal distance is scarcely less in reading*, especially when the desk is not sufficiently sloped. The effect is the most striking in the case of the smaller children. The distance of the form from the desk, and the insufficient support for sitting lead them to prop the head on the left hand, and at the same time to turn themselves to the right about a vertical axis. This brings the left eye nearer to the book than the right eye and makes a good deal more difficult the convergence of the lines of sight, until the right eye is at last left unused altogether. Or the children cross their fore-arms upon the desk's edge and, with heads bent far forward, rest the chin on the back of one hand, bringing the eyes too near the book. They thus exhibit in real life one of the two attitudes, which we so much admire for beauty and grace in the two angels at the feet of the Sistine Madonna, but which must, from a hygienic point of view, be utterly condemned."

The Darmstadt Report recommends none but Lickroth's desks (see below) with a minus distance.

It is very gratifying to find that already even the writing-masters themselves recognise in their manuals the necessity of a minus distance; Director E. Meier[112] in Zwickau, for instance.

(3) *The height of the form.* If the legs are not bent at a right angle at the knee and the feet resting with the entire sole flat upon the foot-board, the feet must be left dangling in the air. Then the child soon grows tired. He tries to reach the floor with the tips of his toes at least; and in so doing he bends the thigh downward, slides forward on to the edge of the form

and presses his chest on the edge of the table. The necessary result is a further collapse of attitude. (In all this we are leaving quite out of account the hindrance to breathing and the compression of the intestines.) *The height of the form must accordingly be equal to the length from the knee to the sole, that is = $^2/_7$ of the child's height.* The knee must be bent at a right angle. If the form is too high, there must be a *footboard* at least 16 centimeters (6·4 inches) wide—wider if possible—so as to take the whole sole. A footboard made of laths placed like a grating may also be recommended (see Fig. XL., Kayser's Desk). No attention is paid to any of these proportions in the old school-desks.

(4) *The slope of the desk.* We can read easily, without any stoop of the head, from a book placed *vertically* before us. If the book slopes back at an angle of 45° with the horizon, reading is equally easy, because the eyes can be directed downward without bending the head forward. But if the book lies flat and the reader sits upright, the eyes are turned downward very far. This, continued for any considerable time, is very tiring and so we prefer to bend the head forward.

It follows that the desk must not be horizontal but sloped. A slope of 45°, however, is not to be recommended, because it would make writing difficult and the writing materials would fall down. A ledge might be put at the edge of the desk to keep the writing materials from falling, but that would cut the arms. A slope of 1 in 6 is the best. The old school desks are all flat and therefore wrong.

It is a remarkably good arrangement to have at the end of the desk a reading-slope, that is a rectangular wooden frame, easily set up by means of two pegs and corresponding holes. Professor Fialkowsky, of Vienna (Bienengasse 4) has made little cardboard reading-slopes, so easily packed up that they can be kept in a book.

In addition to these four cardinal points of the rational school-desk, we have yet to speak of the Back-rest, the Form-width, the Place-width, the Desk-width and the Book-shelf.

(1) *The back-rest.* Meyer has demonstrated beyond all doubt that no one can sit upright for any length of time without a back-rest. The best is one which supports the loins-bone and the lower vertebrae, so steadying the pelvis and making it impossible for the body to slide off the form. Indeed such a support has been in use for some time for music-stools, on which the performer has to sit upright for a considerable length of time, while the hands must be freely moved in playing. "The upright back-rest," says Meyer, "hinders the free movement of the body by fixing an upper point of the spinal column, while the cross back-rest allows perfect freedom of movement, and this freedom, since a change of posture is thereby possible, is the surest means of preventing the fatigue caused by relaxing of the muscles and tension of the ligaments. I have, therefore, no hesitation in giving an unconditional preference to the cross back-rest over the upright back-rest. Fahrner proposed as very cheap a continuous back-support at the level of the loins. But it must be acknowledged that such a back-rest favours in some degree the tendency to crowd as many children as possible into one class. It seems better, therefore, to give each scholar his own separate cross back-rest.

(2) *The width of the form* must be at least 12 inches [30 cm.] so as to afford sufficient support to the seat and thigh.

(3) *The place-width* must not be less than 25 inches [64 cm.], as has been very properly ordered by the Government in Breslau in the rule of June 24th, 1856. By obeying this law over-crowding, too, would be prevented.

(4) *The desk-width* must be at least 16 inches [40 cm.]. In Darmstadt, at Weber's recommendation, it amounts even to 20 inches [50 cm.]. "If," says Weber, "in drawing or writing the fore-arm, supported up to the elbow, is so laid on the desk that its axis makes an angle of 40° with the desk's edge, the perpendicular distance of the point of the pen from the desk's edge, that is, the altitude of the triangle formed by the arm, the desk's edge and the perpendicular from the point of the pen to the desk's edge, amounts to 12 inches [30 cm.]. Now as copy books are generally 8 inches [20 cm.] from top to bottom and as in writing near the bottom of the page the arm must remain unmoved while the copy book is pushed upward, the desk-width must on no account be less than 20 inches [50 cm.], or the arm will be unsupported during half the time it is at work."

(5) *The bookshelves* have also their hygienic importance, as they must not come into collision with the knees. They must be placed so high up as not to interfere with the horizontal position of the thigh. Now as these conditions would place the shelves no more than $3^1/_5$ inches [8 cm.] below the desk, there would scarcely be room for large book-satchels. If, again, the shelves are more than 6 inches [15 cm.] broad, they come into collision with the knees and disturb the erect attitude. It is best, therefore, to have the book-shelf *under the form* or (as is the custom in America) to hang the satchels on hooks under the desk.

From the year 1865, when the first information was published on the connexion of the school desk with short-sight, interest in the school-desk question has been universal. While cases of spinal curvature were detected in but a small proportion of the children, the number of cases of short-sight was enormous. All the medical profession demanded a reform and there was in medical publications an unusual unanimity as to the main points.

The Strassburg report speaks very strongly: "We look upon the doing away of the old school desks as the most urgent necessity of school hygiene. Every half year's delay causes fresh mischief." Weber, in Darmstadt, considers the desk question not only as solved rationally but as, by the proposals—hitherto unanimous—of medical men, solved in a way that can hardly be improved on.

There were but few *teachers* who, in accordance with the medical requirements, endeavoured to construct new models which should satisfy the requirements both of teacher and doctor. Many teachers, unfortunately, were opposed to reform. On the other hand, as was to be expected, *manufacturers* took all the more lively interest in the question.

Since the publication in 1867 of my "Examination of 10,060 School Children's Eyes" a whole school-desk industry has arisen. This industry increases in dimensions year by year. In the Paris Exhibition of 1867 I[113] found only three different models; at Vienna[62] in 1873 there were 47 different kinds of desks, at Paris in 1878 as many as 71, which I have described and drawn in special accounts[63].

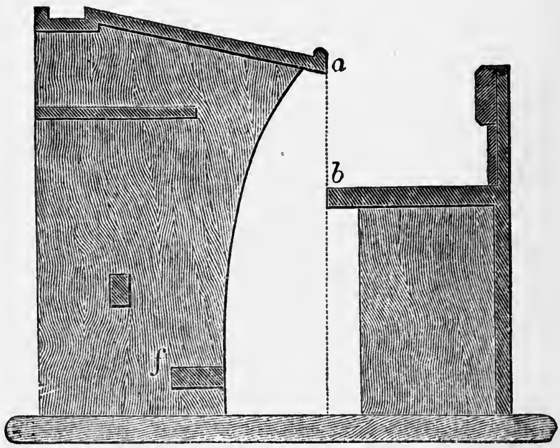
The agreeable fact appeared that the number of desks made on a wrong principle was less in each successive exhibition and that Boards and Governments were more and more taking an interest in school furniture. Thus, out of the 22 desks exhibited in Paris in the year 1878 by ministers or school authorities, only three were made on a wrong principle, all the rest having a nil or minus distance.

It would lead me too far to notice here all the variations tried in school desks since the right principles gained a footing. I shall only mention the chief types. We must distinguish between *(A)* desks with a *fixed nil or minus distance*, and *(B)* desks with an *adjustable distance*.

(*A.*) Among the fixed desks, three models are worthy of notice.

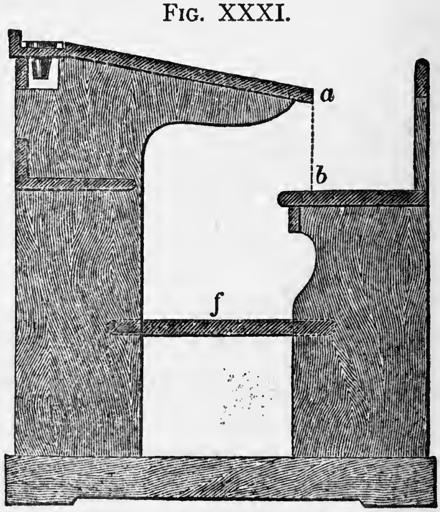
(1) *Fahrner's desk* (Fig. XXX.) This has a nil distance, correct difference, correct height of form and correct slope. It has also a continuous cross back-rest. Correct as this desk is for sitting, standing in it is very difficult, for big children almost impossible. This desk is therefore little used in practice.

FIG. XXX.



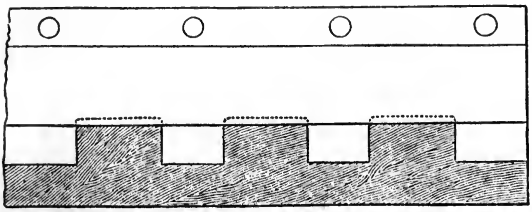
(2) *Buchner's*[109] *desk* (Fig XXXI.). This is on Fahrner's model, only that it has a *minus* distance of 2 inches [5 cm.] and is a dual desk. Each child, when he must stand up, can step out from the desk at the side; and in this act many children stumble over the woodwork which joins the form to the desk. Quite similar is the model of *Buhl* and *Linsmeyer*, only this, instead of a book-shelf, has a book-box, which is attached to the form between the places for the two scholars. In America and Sweden many single-seated models are made on this principle.

FIG. XXXI.



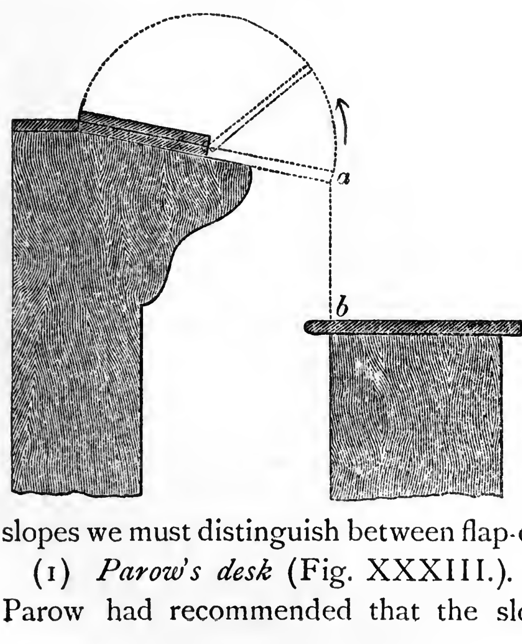
(3) *Löffel's desk* (Fig. XXXII.). In this model from 12 to 15 inches (30—38 cm.) is allowed for each child and next to each place there is, cut out from the desk, a recess in which the scholar can stand.

FIG. XXXII.



All these fixed desks are suitable for *writing;* but it is highly desirable that during the many hours when the child is *not* writing, he should be able to sit comfortably. In this respect all these desks are wanting; not one of them gives the child quite enough room when he is not writing. That he may stand comfortably, as well as sit comfortably, a *positive distance* is required. *Now as it is never possible in one and the same fixed desk to stand comfortably and sit aright, a desk with adjustable minus distance is decidedly preferable.* The tendency of individual scholars to injure movable desks ought to be kept in check by school discipline.

FIG. XXXIII.



(*B*) There are three methods of altering the distance in these adjustable desks. Either the desk-slope or the form, or both may be made movable.

(*a*) Among the desks with movable slopes we must distinguish between flap-desks and sliding desks.

(1) *Parow's desk* (Fig. XXXIII.). As far back as 1865, Parow had recommended that the slope should be divided

lengthwise, and [the movable half] turned down [so as to continue the other] for writing. Keicher, a teacher in Ellwangen, had constructed a special kind of hinge of which the iron part did not come above the surface of the desk. (The drawing may be seen in my "Examination of 10,060 School Children's Eyes.") The Americans have similar flap desks with a very practical little reading-slope at the back (Figs. XXXIV. and XXXV. Peard's study desk). I at first recommended this kind of desk, but I was soon obliged to admit that even the best hinges become loose in time; the two surfaces composing the desk then no longer fit together truly, and the separate parts warp. Moreover, the desk, when half obstructed by the turned up flap, is too small for books and implements; and to clear everything off the desk when the flap must be turned down, has proved very inconvenient.

Fig. XXXIV.

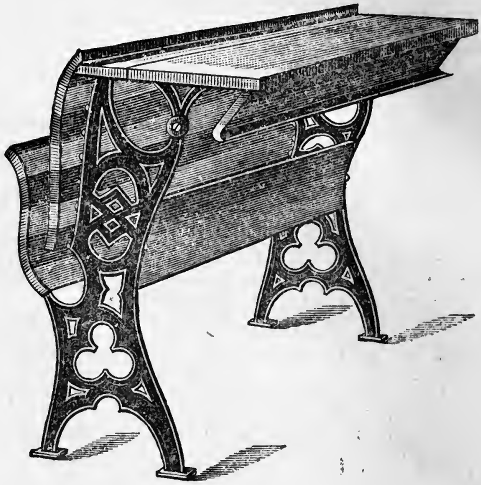
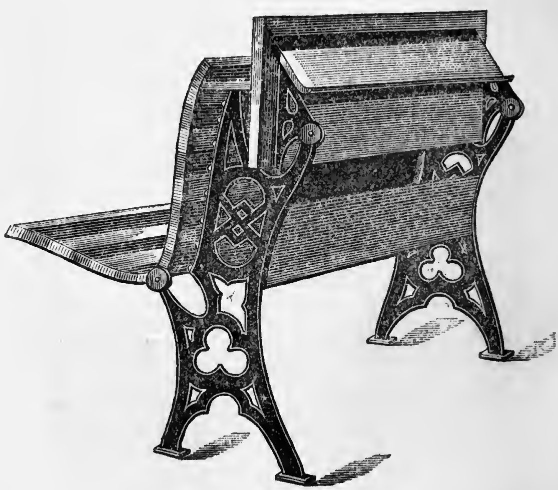


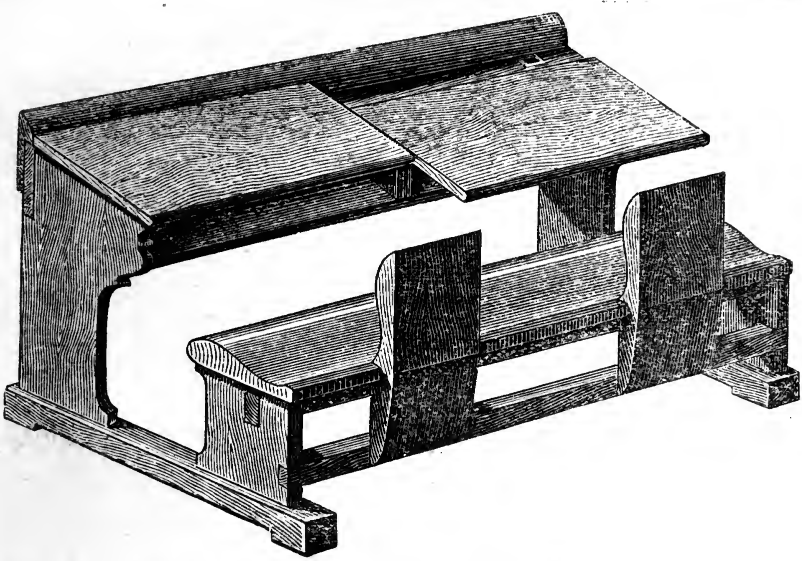
Fig. XXXV.



More practical, beyond doubt, are *sliding* desks, which have not to be cleared.

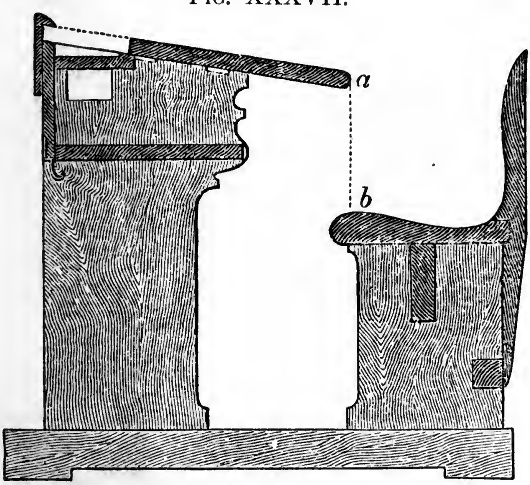
(2) *Kunze's desk* (Figs. XXXVI. and XXXVII.). This desk can be readily drawn out like a "Secretary desk." The mechanism is very complete; the leaf

FIG. XXXVI.



runs in two grooves. When the desk is fixed at a plus distance very convenient for standing, the leaf covers the inkstand so that, for writing, the scholar is *compelled* to draw out the leaf and alter the distance from *plus* to minus, or he cannot get at the ink. There are many varieties possible in the bolts and springs used for securing the leaf when it is drawn out. *Kunze's desk is beyond question one of the best.*

FIG. XXXVII.



Von Reuss states that this desk was at first objected to in Vienna as taking up too much space. Since every desk ledge is made of one fixed breadth which must be added on to the movable drawn-out part, the sunk space which holds the inkstand represents a dead loss of from 4 to 5 inches [10—13 cm.]. Paul, master-engineer in Vienna, made this sunk part (Fig. XXXVIII, *l*.) movable by a very simple lever action (*h*) so that in drawing out the desk, this sunk part (the "self-acting ledge") rises of itself and widens the desk. We can thus afford to make the part to be drawn out correspondingly narrower. With this improvement the model is now being gradually

FIG. XXXVIII.

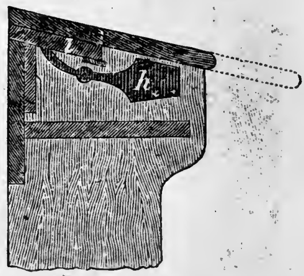
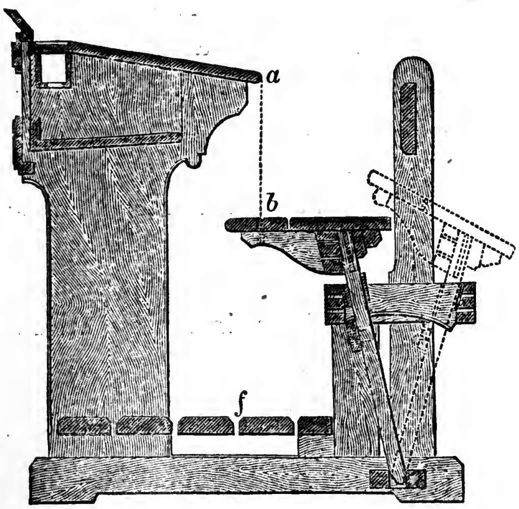


FIG. XXXIX.

introduced into *all* the schools of Vienna under the name of the *Vienna school desk*.

(3) *Cardot's desk*[115] (Fig. XXXIX.). In this desk the leaf is drawn out by turning it upon an iron axle placed under the further edge of the desk. This desk also deserves commendation.

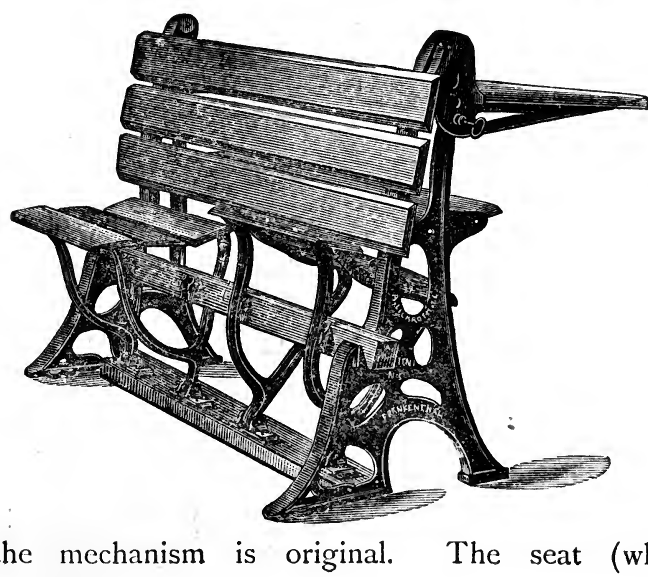
Fig. XL.



(*b*) Of movable forms the simplest are the American (Figs. XXXIV. and XXXV.). In these, when they are made for only one child, the form is simply turned up when the child has to stand. The following are more complicated:

(1) *Kaiser's form*[116] (Fig. XL.), patented. This is, essentially, a seat which lifts up like those in a theatre,

Fig. XLI.



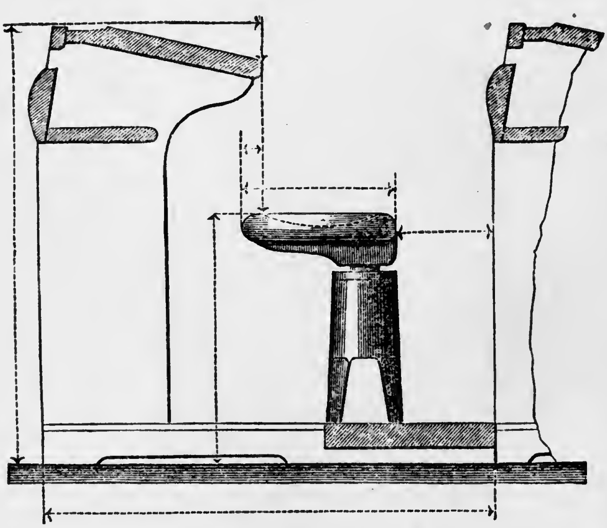
but the mechanism is original. The seat (which of

course is separate for each child) raises itself at a slight push and leaves plenty of room to stand. But the child can never sit with freedom as he can at a sliding or flap desk.

(2) *Lickroth's normal form* (Fig. XLI.). Similar in principle to Kaiser's, but the mechanism is different, as the seat revolves and is arrested by a fixed beam. The movement is very silent, and the seat falls back easily. Iron construction. Thousands of these correct desks are manufactured yearly in Lickroth's large School Desk Works in the Palatinate. They are recommended officially in Hesse.

(3) *Vandenesch's desks.* (Figs. XLII., XLIII., XLIV.). This model allows a more free position in sitting without writing than those I have described. Each separate seat revolves into minus distance in front and plus distance behind and also revolves laterally. The mechanism is shewn in Fig. XLIV. The manufacturer is Vandenesch of Eupen, in the Aix-la-Chapelle district.

Fig. XLII.

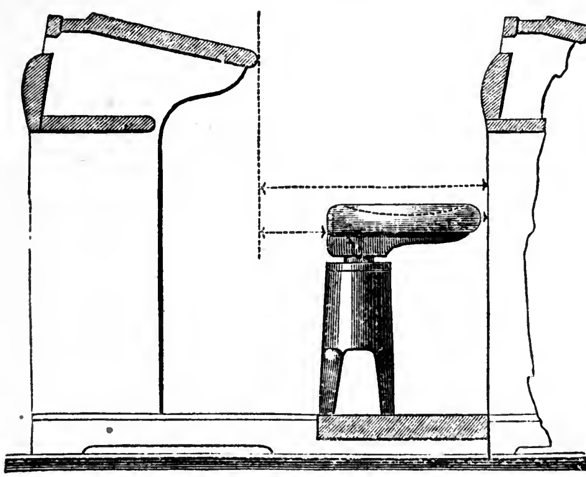


(4) *Hippauf's form* (Fig. XLV.) can be brought forward into nil-distance and back by means of iron

bands. The arrangement (patented) can be adopted with any old-fashioned school form.

(5) *Beyer's form.* A quite new, very cheap and very well planned model by *Beyer* of Breslau, Government Architect (Fig. XLVI.). The phrase *simplex veri sigillum* may be applied to it. The side-boards or cheeks, which support the seat of the form, have at their lower end two elongated eyelet-holes of wrought iron, through which runs a round iron rod. On this

Fig. XLIII.

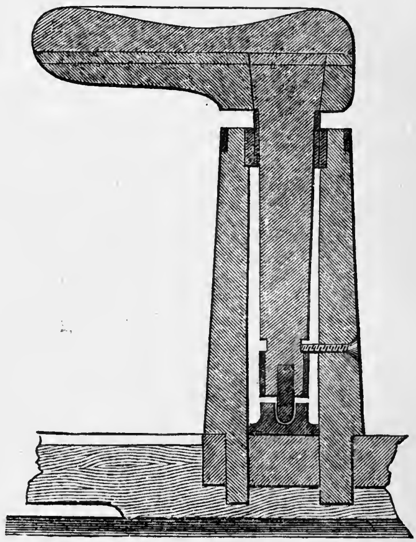


rod the cheek slides backwards and forwards. The iron rod is fastened by two iron angles screwed on to the two cross-beams of the seat, so that the rod runs *across* the form. The form moves without the least noise and without any standing on the part of the scholars, simply by their muscular power. Their thighs are stretched forward in drawing the form up to the desk and in pushing it back. In this way there can be a plus-distance of 5·6 inches [14 cm.] for standing and a minus-distance of 1·2 inches [3 cm.], or more if desired, for sitting. This sliding mechanism only raises the price of a desk for five children by about 2s. 5d., and since the inventor, from interest in the cause, has

declined to take out a patent, it can be affixed *at very little expense to any old-fashioned forms.*

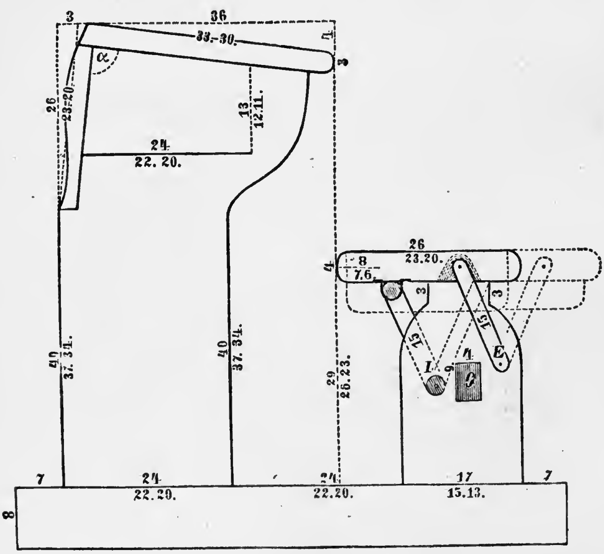
We see, then, that there is no longer a lack of models, excellent from a hygienic point of view. It may be left to the teachers to choose from among them that which appears the best for teaching purposes.

FIG. XLIV.



Every manufactory has now its *tables of desk-measurements* suited, according to the accepted principles, for children of all heights. They may be seen in the prospectuses of the School Desk Works of Wolf and Weiss of Zürich, Lickroth of Frankenthal,

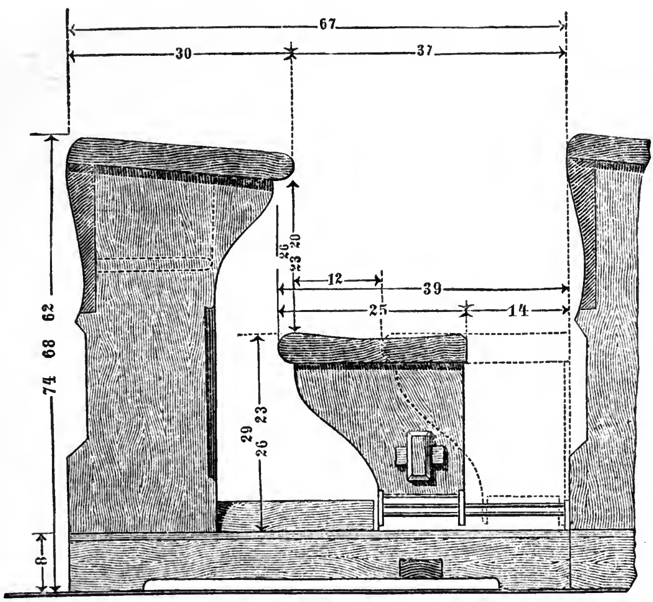
FIG. XLV.



Bahse and Hähndel of Chemnitz, Lenoir of Paris and Vandenesch of Eupen.

For scholars whose height varies from 3 feet 4 in. to 6 feet [100—180 cm.], eight different sizes of desk are sufficient. In order to fix some standard, I give here the admirable Table of Measurements for flap dual desks

Fig. XLVI.



published after very careful discussion and observation by the School Desk Commission of the town of Zürich. (Cf. Die Schulbankfrage in Zürich. By A. Koller, Zürich, 1878.)

TABLE OF MEASUREMENTS FOR SCHOOL DESKS.—ZÜRICH TOWN.

Age of scholar	6—7	7—8	8—9	9—10	10—11	11—12	12—13	13—14
Height in inches	40·4—44	44·4—48	48·4—52	52·4—56	56·4—60	60·4—64	64·4—68	68·4—72
,, ,, centimeters	101—110	111—120	121—130	131—140	141—150	151—160	161—170	171—180
Number of desk	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Vertical height of slope (inclination 14°)	3·2	3·48	3·6	3·8	4·	4·	4·	4·
Vertical interval, desk-surface to seat	7·6	8·0	8·4	8·8	9·2	9·6	10·4	11·2
,, ,, seat to footboard	10·4	12·0	13·6	14·8	16·0	17·2	18·4	19·6
,, ,, footboard to floor	8·8	6·52	4·4	2·6	0	0	0	0
Total height of desk	30·0	30·0	30·0	30·0	29·2	30·8	32·8	34·8
Form.								
Seat-surface above floor	19·2	18·52	18·	17·4	16·	17·2	18·4	19·6
Width of seat up to vertical line from desk-edge	9·2	9·6	10·	10·4	11·2	11·8	12·8	13·6
Height of seat-support	15·76	15·08	14·56	13·96	12·56	12·96	14·56	15·76
Back Rests.								
Lower support. Lower edge above seat	4·8	5·6	6	6·4	6·8	7·2	7·6	8·4
Upper support. ,, ,, ,, ,,	7·6	8·	8·8	9·2	9·6	10·	10·4	11·2
Breadth of upper support for boys	3.2	3·2	3·2	3·2	4·	4·	4·	4·
,, ,, ,, ,, girls	4·	4·	4·	4·	4·8	4·8	4·8	4·8
Desk.								
Width of slope	13·6	14·4	15·2	16·0	16·8	16·8	17·2	17·2
Fixed part of the slope	6·4	7·2	8·0	8·8	9·6	9·6	10·0	10·0
Width of flap	7·2	7·2	7·2	7·2	7·2	7·2	7·2	7·2
Width of top ledge	4·4	4·4	4·4	4·8	4·8	4·8	4·8	4·8
Width of book-shelf	8·0	8·0	8·0	9·6	9·6	9·6	10·8	10·8
Open space between book-shelf and under surface of slope	5·8	5·8	5·8	5·6	5·6	5·6	5·6	5·6
Length of slope and flap	48·0	48·0	48·0	48·0	48·0	48·0	56·0	56·0

NOTE.—The meter is assumed = 40 inches. [ENG. ED.]

In conclusion, I would point out that while the scholars *must* sit badly in the old ill-constructed desks, they *may* sit badly in the best of the new ones. Attention to attitude on the part of teacher and scholar will be necessary with any desk. The main point is that *the eyes must not come too close to the work.*

Unfortunately there are many teachers who require, even in a writing lesson, that the scholar rise when called on. If, to meet the demand of these teachers, desks with *positive* distance are still brought into schools, and if, moreover, on account of the teacher's order of merit (a thing in itself very desirable) the children are not placed in desks suited to their size, but big and little together just according to their mental capacity, this shews *an unjustifiable depreciation of the efforts made by medical men to prevent the increase of short sight.*

If formerly Prussia was far behind other states with reference to proper school desks, it is all the more gratifying to find that a decree issued in Breslau, 27th December, 1881, directed the attention of all magistrates, district school inspectors, and town school-authorities to the importance of *minus distance* in writing and recommended the inexpensive contrivance of Hippauf, or the desks made by Lickroth of Frankenthal, or those made by Vandenesch of Eupen. This excellent decree says: "To arouse the interest of local inspectors and teachers in this important question, for the beneficial solution of which they can often exercise a considerable influence, we further resolve that in every *General Conference of Teachers* held during the next year, the school desk in relation to the health of the scholars, to teaching and to school discipline, shall be thoroughly discussed. . . . Lastly, we enact *once for all* that in every case of the *opening of a new school* or the *re-furnishing of an existing school,* a report shall in the first instance be made to us, *stating the kind of school*

desks proposed, and on what grounds the selection has been made, in order that we may approve or reject the selection before the desks are introduced."

Chairs and desks for *University lecture rooms* have been for years adopted by Professors Sämisch and Förster; but, as Köster truly observes, "The chairs are all of equal height, and the students are not." Professor Köster has accordingly, since the beginning of his career in Bonn,* introduced into his lecture room Viennese revolving stools, which the students, before the lecture begins, can properly turn to suit their vetebral column and their short sight. These seats, to be sure, have no backs.

Just as important, of course, are *good desks at home* as good desks in school. Many manufacturers produce home desks, which can be altered in dimensions so as to keep pace with the child's growth.†

But without any special desk, it is very easy to make at home a proper seat for any child at any sort of table, with the help of *footstool* and *cushion,* if we only attend to these three main points:

(1) The seat must be of such a height that its vertical distance from the table equals the distance of the elbow from the seat-bones *plus* 2 inches [5 cm.].

(2) The chair must be pushed so close up to the table that the upper edge of the table overhangs by 2 inches [5 cm.] the fore edge of the chair.

(3) A footstool must, if necessary, be used, so placed that the feet rest flat upon it while the knee is bent at a right angle.

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* Communicated by letter.

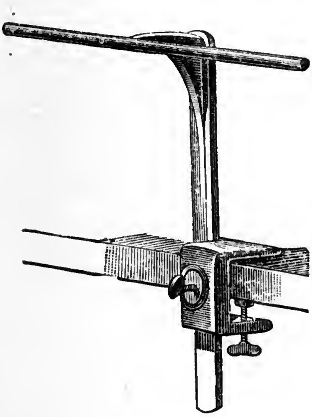
† Very good home desks may be had at Priebatsch's, Breslau (Ring 58.) Price 30 marks.

CHAPTER TWELFTH.

STRAIGHT-HOLDERS.

Quite recently school-desk reform which, on account of expense, teachers and school authorities do not like to see, has taken a completely new phase through the invention of useful *Straight-Holders*. These at least enable us in the case of *old* schools to make the desks, without altering them, somewhat less hurtful to the scholars.

FIG. XLVII.

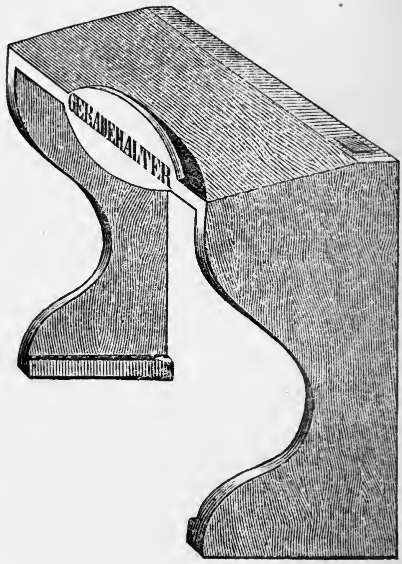


(1) So early as 1858 Schreiber[64] invented a straight-holder (Fig. XLVII.). It consisted of a level rod, fastened to a vertical bar of iron or wood. The bar was screwed on to the table in such a manner that the rod was at exactly the same heighth as the child's collar bones. Whenever the child stooped forward, the rod pressed him, and the pain thus caused reminded him to sit up! Such an instrument of torture as this was unable to make its way into use.

(2) In the Paris Exhibition of 1878 I found a desk made by Happel of Antwerp, which had a so-called straight-holder (Fig. XLVIII.). The edge of the table was somewhat hollowed out into an oval, and in the hollow was a *wooden disk* about 12·8 inches [32 cm.] wide and 9·6 inches [24 cm.] high. The disk was hollow in front, and was meant to receive the child's chest and to prevent his leaning forward. Of course this apparatus

merits the strongest condemnation; for such a board *presses* on the chest, and pressure on the chest is quite as mischievous as stooping forward.

Fig. XLVIII.



(3) In 1880 Dr. L. Heffter and Theodor Schuppli of Zawiercie devised a real support for the child. They called it a *Writing-Crutch* and took out a patent for it. They have forwarded four different samples to me and have also published a book of diagrams shewing 45 different variations of the "crutch." (Some of these will be found in Fig. XLIX.) The inventors have

Fig. XLIX.

bestowed all imaginable ingenuity on perfecting the working of the mechanism; and yet the crutches can hardly

be recommended, not being designed on any right principle. The crutch consists of a crossbar which is placed close to the throat, under the chin. In this way there is easily caused an unpleasant pressure against the "Adam's apple," impeding the breathing. To escape from this pressure the child pushes his chin about and has difficulty in finding a position of rest, especially as most of the crutch models have not the means of being *securely* fastened to the table; rather is the pressure of the child's head relied on to hold the crutch to the table by means of a bar which slants downward. In but a few models there are sharp points fixed to the lower end of the crutch, which are intended to be stuck into the table. The crutches, which are made of wood or metal, in course of time more or less gall the skin. Only one model had a leather *strap* to be placed under the chin. As far as my own experience goes, I find that children cannot work for any considerable length of time with these too unsteady crutches.

Dr. Heffter very rightly observes in a letter: "In cases where any pain whatever prevents the application of the crutch to the throat, cross pieces can be added for the chin to rest in."

Fig. L.

(4) This idea has been found by Soennecken* of Bonn to be the best for all children, whether suffering in the throat or not. He informed me in November, 1881 that he had accordingly acquired Heffter and Schuppli's patent. His *Writing and Reading Support* (Fig. L.) is a true *chin-holder*, made of wood in different sizes and fastened in a slanting position to the

* Cf my address at the sitting of the Breslau Trades' Union, 14th November, 1882. Breslauer Zeitung, No. 823, and Schlesische Zeitung, No. 872.

edge of the table by means of a simple but strong steel spring. The mechanism for the supports, which have to be placed at various heights, is very simple and ingenious, but not sufficiently reliable to ensure that the apparatus shall keep at the same height.* Besides, the pressure of the child's finger can easily push the movable supports out of the proper height into a wrong height. Many children, again, with tender skins complain that the plate hurts their chin. I therefore prefer unalterable supports, fixed at the proper height. But even these fixed supports cannot be used in reading aloud, because they move up and down with the lower jaw to the great amusement of the children. Again, the support does not *compel* the child to sit straight; if he wishes to lean down, he just pushes the little support on one side. Nevertheless Soennecken's support, especially when at the proper height, is much better than no support at all; in any case it reminds scholar and teacher about attitude; its price is remarkably low (from 3d. to 1s. 5d.); and it might be greatly improved by coating the chin-plate with india-rubber and in respect of fixture.

FIG. LI.

More recently still, Kallmann, an optician in Breslau, has succeeded in making a very useful *Face-Rest* (Fig. LI.) which can be screwed on at various heights to any table. It has an iron ring enclosed in india-rubber so as not to hurt the face which rests against it. (Thus supports have gradually climbed from the chest to the collar-bones, the throat, the chin and lastly the face). When once the Face-rest

* The newest models are more satisfactory in this respect.

has been screwed on to the desk at the proper height, the key can be kept by the teacher. I cannot do without this rest in the case of children beginning to write and read; and *I never allow my own children to write without it, whether at home or in school, even when sitting at the best possible desk.* It does not cause the least annoyance in writing; the children soon grow accustomed to it; and even with old, wrongly-constructed desks, that is with plus-distance, it is *impossible* for the child to bend his head down, even if he is more perched than seated upon the form. The face-rest is, therefore, a very valuable corrective to the old school desks. Of course the apparatus must be screwed on at the proper height. The introduction of this rest into schools and private houses cannot be too strongly recommended. The price* is certainly high but there should be a considerable reduction in price for schools. There is no doubt that the right position of the child is better secured with Kallmann's face-rest than with Soennecken's chin-support.

Both of these last mentioned straight-holders have been recommended to the school authorities by the Prussian Government in Frankfurt-on-the-Oder, Königsberg and Breslau, with an interest that deserves grateful mention. The Royal Provincial School College at Breslau obtained from the Royal Provincial Medical College a valuable report, and forwarded it on the 3rd of November to the directors of all the Silesian Schools. The report is dated October 10, 1882 and says:†

"Soennecken's writing support is one of the artificial aids to the prevention of a bad posture in writing and therefore of the consequences of a bad posture, namely, spinal curvature and short sight. We must first say with regard to all these artificial aids that their effect will be illusory if the school forms and desks and the

* It varies according to the mechanism of the screw from 2 to 6 marks.

† Schlevische Leitung, Dec. 15th, 1882, Nr. 881.

home writing-desk do not conform to sound hygienic principles. But if the school desks and forms are rightly made, a straight posture in writing will be attained with more ease and security by a healthy adjustment of these desks and forms than by any artificial supports, which impede far too much the writer's movements at the school desk and which are soon felt to be a restraint, and then after all do not effectually prevent a bad posture of the head. But in cases where the school desk is not properly constructed for writing or not provided with a normal seat for writing and reading, writing supports have their use and are not without beneficial effect. Among these writing supports Soennecken's deserves a high place. It secures (to mention its good points first) with tolerable certainty *the position of the head at the right distance from the copy-book.* This good effect is not completely attained, because, even when the chin is resting upon the support, it is possible to turn the head towards the left and bend it forward, a movement which is always the beginning of a bad writing attitude and one which is regularly adopted by the children when, after writing for some time, they begin to feel the chin irritated by the plate. Kallmann's *face-rest* secures the position of the head at the right distance somewhat better (though not perfectly); the top part of it provides a much broader support which encircles the whole forehead; and the support does not gall, so that it causes no change of posture. A very intelligent teacher, Herr Döll, of Kreuzburg, has established this fact by a series of experiments. *A second great advantage of Soennecken's writing support is its cheapness.* The non-adjustable writing supports, No. 1, are sold by the hundred at threepence each, and can therefore be used for whole schools where wrongly made desks are still in use; that is, desks where the form is not at the right horizontal interval (distance) and vertical

interval (difference) from the desk. This is the point in which Soennecken's writing support manifests a great advantage over Kallmann's straight-holder. The latter costs six shillings, and is therefore not adapted for use throughout a whole school in a poor district, where money cannot be raised to provide proper desks. Soennecken's writing supports, on the other hand, can be procured by the poorest community for all its children; and then the *serious evils resulting from the faulty construction of desks* are, at least in part, prevented. This, therefore, is our final decision: Soennecken's writing support is to be recommended for scholars and private persons who are unable to procure the proper kind of desks: Kallmann's face-rest attains the object desired more surely than Soennecken's apparatus, because it supports the head more completely and more comfortably,—but this advantage, in the case of schools, is at least fully counter-balanced by the greater cheapness of Soennecken's writing support."

However much one may agree, on the whole, with this admirable judgment of the Royal Medical College there is one point open to objection. Even with a *good* desk the straight-holder is not superfluous. I have seen again and again that children have a tendency to stoop forward, even at the most un-exceptionable desks; while with Kallmann's face-rest, they are compelled to sit in a good position permanently. I especially recommend it in the case of those desks which have, very properly, a little reading slope at the far side. Then the face-rest, which with Kunze's desk, when the leaf is drawn out, is 20—24 inches [50—60 cm.] from the book, *compels* the child to read from the book at that distance and therefore with the minimum of accommodation-work and with head upright. *The face-rest will certainly contribute to the prevention of short sight.*

The Report of the Royal Medical College, however, has an important bearing on a wider subject than the question of the face-rest. In asserting *the pernicious effect of positive distance* between desk and form, it opposes with all its scientific and official authority the fatal error of too niggardly school-managing bodies who, *as is unfortunately the case in Breslau to this day*, furnish even the newest schools with desks *injurious to health.*

May this praiseworthy step on the part of the State be the happy guarantee of a victorious battle against short sight.

CHAPTER THIRTEENTH.

DAY LIGHTING OF SCHOOLROOMS.

It has been known for centuries that, the dimmer the light, the nearer the eye must be to the page. It is therefore a riddle why in the building of schools the position, size and number of windows have not long ago received that care which is so necessary in the interest of good eyesight, and why we continually find authors saying that this or that schoolroom "gives the impression of being most insufficiently supplied with daylight."

In my investigations in Breslau I have drawn up a *Light - Table* for every schoolroom, based upon the following questions.

How many windows are there at the right, left, front and back of the writer?

How many windows facing east, west, north, south?

Of what colour are the walls?

How high are the opposite houses?

How far off?

Of what height and width are the windows?

In what storey is the room?

I was obliged to content myself with these data, since at that time there was unfortunately no photometer to measure the degrees of daylight in somewhat the same way in which we could measure heat. I observed, while thus engaged,* that for comparing the lighting of two rooms *the human eye itself* is in some cases the best photometer. For example, a healthy eye, which can read at a distance of 40 inches [1 meter], will find it difficult, although the daylight may be the same, to

* Cf. my Essay on the Examination of the Eyes of 10,060 School Children, page 101. 1867.

read the same type at only 20 inches in a room lighted by one small window. Since then, Von Hoffman[14] of Wiesbaden has put this idea into practical shape by advising that in every classroom Snellen's test types be hung up, and lessons ended as soon as the daylight is not strong enough to allow a healthy eye to read type No. 6 (Fig. XIV.) at a distance of 20 feet [6 meters]. This advice is well worth taking to heart.*

The Strassburg Medical Report (Prof. Laqueur) would like the daylighting to be such as to allow small diamond type to be read with ease at 12 inches, even by the scholar furthest away from the window.

Let us turn now to the separate points in my Light-Table.

1. *Position of the windows with regard to the cardinal points.* Among 724 windows in 166 classrooms in Breslau I found 171 facing east, 133 west, 210 north and 210 south. At one time, therefore, people built without the slightest reference to this matter. And yet there can be no doubt that, other things being equal, windows facing south admit more light into a room than windows facing north. How greatly the degree of light depends upon the position of the windows will be best seen from the fact that a number of children in the Zwinger Real School at Breslau, who could not distinguish my reading tests at 4 feet in a room facing north, were well able to do so in a room facing south, on the same floor, with windows of the same size and with surroundings equally clear.

* While these sheets were in press I received the work of Bertin-Sans of Montpellier: Le problème de la Myopie Scolaire. (Annales d'hygiène publique, tom VII. pages 46 ff. und 127 ff., 1882.) The author describes a school photometer similar to Rumford's. A candle casts the shadow of a stick upon a screen; as the candle is removed further off the shadow gradually grows fainter and at last disappears altogether. The lighter the room the sooner the shadow disappears. If it disappears in one room when the candle is 8 inches [20 cm.] away and in another when the candle is 12 inches [30 cm.] away, the degrees of light in the two rooms will be as $8^2 : 12^2 = 4 : 9$. Now, if broad daylight (grand jour) be taken as $=1$, since in broad daylight the shadow disappears at 1 centimeter [$\frac{3}{8}$ of an inch], the light in the second room is to broad daylight as $1^2 : 30^2 = 1 : 900$. Prof. Bertin informs me by letter that he is still personally occupied in improving his photometer.

The best aspect for windows is *east* or *south.* The rays of the morning sun warm the room pleasantly; the wind seldom comes from the south-east in Germany; and it is easy by means of blinds to protect one's-self from too hot or too bright sunshine. Windows facing west have this disadvantage, that the afternoon's school work is too short for gaining the full benefit of them.

I adhere still to the opinion I expressed eighteen years ago that *there can never be too much light in a school.* Javal[65] also now fights for the freest possible lighting. He says most truly: "*The school must be flooded with light, so that the darkest place in the class may have light enough on a dark day.*" Most writers are for windows looking east and south-east; for instance, Zwez[66], Varrentrapp[67], Falk[68], Pappenheim[69], Javal and Baginsky[70]. Lang[71] and Reclam[72] alone prefer a north aspect; against which the fact that the rooms are then more difficult to keep warm is an additional argument.

2. *Number and size of the Windows.* This point is of the greatest importance. The fewer and smaller the windows, the darker the room. I found windows only 42 inches high by 30 inches wide. I have proposed that for every square foot of floor there should be at least 30 square inches of glass; that is, one square foot of glass to every 5 square feet of floor. Rooms built in accordance with this principle were found, *cæteris paribus,* to be sufficiently lighted. Instead of this I found in Breslau, I am sorry to say, schoolrooms with 1 square foot of glass to 8, 10 or even more square feet of floor.

On the other hand, I certainly saw rooms with 1 foot of glass to 4 feet of floor, which were nevertheless much darker than those mentioned above, owing to high buildings outside which intercepted the light.

But how far, even at Exhibitions open to the world, we fell short of hygienic wishes, was proved to me by

the measurements which I[73] took of the school buildings at the Paris Exhibition in 1867. I found there:

In the Prussian schoolroom 16·7 inches (instead of 30) to 1 foot of glass,

though in the American schoolroom 32·2 inches to 1 foot of glass.

In the Vienna Exhibition of 1873 I found[62] to 1 foot of floor:

In the Portuguese schoolroom . .	17·6	inches of glass
„ „ American „ . . .	20·6	„
„ „ Norköping school . . .	25·7	„
„ an Austrian „ . . .	26·5	„
„ Schön-Priesen school . . .	28·6	„
only in the Swedish „ . . .	32·0	„
and in the model of the Franklin school at Washington	52·8	„

No one can deny that there has been an improvement of late. In the last Paris Exhibition[63], 1878, I found in the Ferrand School-house 60 square meters of glass to 55 of floor, that is, about as much glass as floor. This was the most excellently lighted schoolroom I ever saw.

From Baginsky's[70] statistics we have the following proportions:

	Window surface.		Floor surface.
Catholic Publ. El. School, Frankfurt-A.-M. .	1	to	8·7 (Varrentrapp)
Middle School „ „ .	1	to	10
Higher Municipal School „ „ .	1	to	8·9
Jewish Real School	1	to	9.8
Crefeld Publ. El. School	1	to	5 (Buchner)
Berlin Schools	1	to	9, 8, 7 respectively (Falk).

The enactments of the Ministry of Education in Saxony, April 3rd, 1873, make the ratio 1 to 6 and 1 to 5. The Württemburg decree of December 28th, 1870, 1 to 6 and 1 to 4. The Royal Technical Architect's Deputation in Berlin, which accepted my minimum proposal, makes the ratio 1 to 5. The Frankfurt Report says that the glass should equal in area 1/3 of the room's longest side.*

* "The State," says Prof. Pflüger[24] very justly, "which asks a minimum of educational results from the school, ought at any rate to prescribe a minimum ratio of window surface to floor surface. A total disregard of this ratio is a *great sin of omission* on the part of the State."

Of course only glass-space can be counted; cross wood-work and drapery cannot be included. Varrentrapp[67] complains that the want of light in the Frankfurt schools is caused partly by the "beautiful" piers and partly by architecture and solid wood-work which take up one-third of the window space. In the Frankfurt schools the window-space and glass are as 40 to 26, 24, 29. In the new Magdalen Gymnasium at Breslau too much room is usurped by wood-work.

Another point of importance in the lighting of rooms is this: The piers between the windows should not be rectangular but bevelled on the inside. The base of the window, however, should not be bevelled, lest the light fall too far below the desk and a troublesome reflexion be caused. There must be at least 40 inches [1 meter] between the lowest edge of the window and the floor. Would that windows were lengthened above instead of below!

Erismann, in his latest work (School Hygiene, p. 49) gives* the following scheme for the size and arrangement of windows:—

Length of wall:	
Pier at one end of the room . .	5 feet
Four window recesses (at 5 feet) .	20 „
Three piers between the windows (at 1 foot)	3 „
Pier at the other end of the room .	3 „ 4 inches.
Length of the room .	31 feet 4 inches.
Height of wall:	
From floor to lowest edge of sill .	3 feet
Height of window recess . . .	10 „ 8 inches.
Distance of highest part of window from ceiling	1 foot 4 inches.
Height of room .	15 feet.

The window itself would be 4 feet wide by 10 feet

* In meters. The meter is here taken as = 40 inches [Eng. Ed.]

high, having therefore a surface of 40 square feet. Four windows would thus have a surface of 160 square feet. Supposing the room to be 23 feet 4 inches wide, the glass surface would be to the floor surface about as 1 to $4^1/_2$.

Just as insufficient lighting can do mischief, so can *perverse* lighting. A. Weber[44], in his admirable report to the Hessian Ministry of Education, 1881, was the first to draw attention to this point. The bad effect of obliquely incident light can be inferred from the shading of the eyes by the hat-brim or the hand. Weber shews that "the delicate retinal picture does not come to perception because, owing to the circles of diffusion, the *adjacent* nerve-elements are, through interference, excited almost as strongly, or even more strongly by the light incident in all directions." He thinks also that the incidence of light in all directions causes an immoderate consumption of rhodopsine which (see Chap. II.), produced by the retinal epithelium, fills the exterior parts of the rods and so prepares the retina for the reception of the picture. "The replacement of this rhodopsine requires from 2—3 hours, according to the degree of its effacement at the place of the retinal picture. Its accumulation is intimately connected with the retina's power of perception, although considerable, nay even organic differences obtain here."

Dark eyes, in which the pigment-stratum is more fully developed, enjoy a more energetic production of the rhodopsine, and consequently a higher power of retinal perception than eyes of a *light colour.* Weber concludes from this that the eyes of children, which always contain a smaller amount of pigment, are more quickly exhausted by perverse lighting than those of adults.

According to Weber, another injurious effect of perverse lighting is the setting free of *higher conditions of refraction* not corresponding to the distance of the object;

for the contraction of the pupil caused by the increased amount of incident light is accompanied by a corresponding contraction of the accommodation muscle, a contraction requiring that the object be brought nearer to the eye. Another effect is that from 1 to 5 per cent. of the school children suffer from *spots on the cornea*, and that these children see much worse in a side light, which is diffused at the spots and dispersed over the retina. (In the year 1865 I found 211 school children out of 10,060, or 2 per cent., suffering from spots on the cornea.)

Of course no perverse lighting is possible when the room has its light *from above.* The Strassburg Report advises that, when the lowest edge of the window is less than 40 inches (1 meter) from the ground, the lower panes should be covered with dark curtains or wooden shutters. In my own opinion perverse lighting is never so dangerous to the sight as too scanty lighting.

Kleiber[74] thinks it better to have *three* windows than two, even if the two windows have just as much glass as the three. For since the light decreases, not as the distance, but as the *square* of the distance, the more distant scholars receive less light from two windows than from three.

The best plan seems to me to be that adopted in photographers' or artists' studios, where the whole of the left side of the room consists of windows separated from each other only by small iron supports. This method is easily carried out in one-storied buildings, as Ferrand[63] shewed in his model school-house in the Paris Exhibition of 1878.

The lighting of the Microscopic Hall in the Pathological and Anatomical Institute at Breslau is also worthy of imitation. Three windows facing north, two facing east, with total glass surface 23·20 square meters to 62·64 square meters of floor, that is, 1 glass to 2·7

floor. There are no dark corners in the room. And children who are learning to read and write need just as much light as students learning the use of the microscope.

3. *The position of the windows with respect to the writers* must also be considered. Everybody knows that he can best see to write when the light falls from the left. If it comes from the right, the shadow of the hand is thrown upon the paper, and the eye has to be brought nearer to the paper. When I examined the Breslau school children 18 years ago, I found 106 windows on the right of the desks, 62 in front, 93 behind and 463 on the left. In four rooms the only windows were in front of the children or behind them. In 43 rooms out of 166 there were windows on the right, though there were only 3 rooms in which the windows were *exclusively* on the right. This bad arrangement was rectified in a few minutes by merely changing the position of the desks.

Ellinger,[75] also, found in the physiological lecture room in Würzburg, in 1858, that the desks were arranged for the light to fall from the right. "No doubt," says Ellinger, "in this lecture room once a year was expounded the well-known proposition about the intensity of light and the square of the distance, and the consequence was deduced that if the paper is thrown into shadow a larger retinal picture is required, and therefore a nearer approach of the eye to the paper, and that not in simple but in duplicate ratio. It is easy to understand that chronic myopia is developed by this means, and that by such indifference young medical students are not trained to discover the best light for their own and, afterwards, for their patients' writing. According to information obtained so recently as 1876 the desks in the physiological lecture room in Würzburg were standing in the same position in which the

joiner had placed them 24 years before. In half-an-hour and without any inconvenience the desks of students and lecturer could have been turned round." Erismann found a similar state of things in Petersburg. Blasius reported in 32 per cent. of the school-rooms of the Duchy of Brunswick a right-hand, and therefore, a faulty lighting.

When I found in Breslau in 1865 one-seventh of all the windows to the right of the scholars, it showed how little attention had been paid to the government decree of the 24th of January, 1856, which ordered that "the arrangement of the desks in the schoolroom should be such that as far as possible the light may fall from the scholars' left." Falk[68] found in the majority of Berlin Schools, and afterwards Baginsky[70] found in *all* the Berlin Schools, the windows on the scholars' left.

If the windows are only *in front* of the children, none but those sitting on the first forms have sufficient light. If there are windows to the left as well as in front, the front windows certainly add to the amount of light in the room, but they are troublesome, because the scholars are dazzled by the front light when looking at the black-board placed between or before the windows and also because it is difficult, and often impossible, to see what is written or drawn upon a board so placed.

Windows *behind* the desks are not injurious to the children, provided that there are enough windows on the left; but (according to Thomé[76]) they dazzle the teacher and make it difficult for him to superintend the class.

Until a short time ago most writers were inclined to the opinion that the schoolroom should be lighted exclusively from the left. Recently, however, the proposal has again been made in France to light the room on two sides, in order to give more light generally and allow a better ventilation.* Such a schoolroom, designed

*Cf. the discussions which took place on this question in the Société d'hygiène publique at Paris between Trèlat, Javal, Gariel and Laynaud. (Revue d'hygiène, 1879, p. 576 ff., 658 ff. and 1021 ff.)

by Ferrand, we found in the Paris Exhibition of 1878. He admitted the injurious effect of windows *of equal size* on the right and left of the children, and therefore adopted the "Eclairage bilatéral avec intensités lumineuses différentes" recommended by Dr. Galezowski of Paris. To the left of the child was an immense window 10 meters [about 33 feet] high; while to the right there was a window, high up in the wall, 5 meters high. The principal light thus came from the left; there were no cross lights on the desk, because the window on the right hand extended downwards only 5 meters (16½ feet) from the ceiling. The shadow fell from left to right in writing, and yet there was on the whole more light in the room than is obtained by one-sided lighting. Javal also finds one-sided lighting insufficient for large schoolrooms; small rooms only 4 meters (13¼ feet) wide are sufficiently lighted, he considers, by windows facing north. The Strassburg Report advocates windows on opposite sides only for large schoolrooms, in order to prevent the crowding of the scholars towards the window side of the room and to obtain more light in the room.

On the other hand, Erismann and Trélat unhesitatingly pronounce light coming from the right to be extremely injurious. I agree with them: for, while the strongest contrast of black and white is desirable, both in print and in hand-writing, a right-hand light throws the shadow of the hand on the very spot at which the eye has to be most keenly directed.

The ideal schoolroom, from an oculist's point of view would have a glass roof. Roofs of this kind have long existed in America. So far back as sixteen years ago, I expressed a wish for this method of lighting (page 118 of my Untersuchungen) and since that time the plan has been warmly approved for school-barracks by Gross of Ellwangen, who has given drawings. He says,

with perfect justice, that anyone who has been in a modern weaving mill must be convinced that no dark corner can exist in the most gigantic room which has a glass roof.* Javal, too, considers a glass roof to be the best. Of course, with glass roofing, schoolrooms could have only one story, and in towns, where land is dear, that would be scarcely possible. But the light should come from above at least in rooms where drawing is taught, and, according to Guillaume's[78] advice, in rooms where lessons are given in geography. Weber also desires that girls' sewing lessons should be given in rooms so lighted. These class rooms could all be placed in the top story.

4. *The surroundings of the School.* It is self-evident that the best position of windows with reference to the cardinal points, the largest and broadest windows and plenty of them are not enough for good lighting if the outlook is blocked by trees or *high neighbouring houses* or very high churches. Zwez[66] thinks that a house opposite does not materially injure the school if the angle of elevation, measured from a window-sill of the school, does not exceed 20 or 25 degrees. Javal[65] demands with reason that *the distance of the opposite buildings should be equal to twice their height.*

How our predecessors have sinned in this very matter is shewn, among other instances, by the situation of the Elizabeth and Magdalen Gymnasia in Breslau, which were built centuries ago only 50 or 60 feet from the highest church in the town and provided with very narrow courtyards. But the entire re-building of the Magdalen Gynmasium in 1867 upon the same site, and without considering, at that date, that the church must intercept the light from many of the class rooms, is one

* In Rosenthal's Weaving Mill, in Schweidnitz, I saw three rows of glass panes in the roof, each of them 1·66 meters high by 41 meters broad [about 5 feet 6 inches by 1 foot 4 inches]: that is 204 square meters of glass to 768 square meters of floor. The weaving mill was therefore lighted brilliantly.

of the many inexplicable things which are met with in practical school hygiene.

In comparing the lighting of the class-rooms with the number of short-sighted children I found in 1865 that *the narrower the street in which the schoolroom was situated the higher the opposite houses, and the lower the story on which the lessons were given, the more numerous the cases of myopia among the elementary scholars.* I purposely say *elementary* scholars. This was a question, not of two or three schools, but of 20, all having the same standard of work for the children; a question, therefore, not of a freak of chance but of a law. *Twenty* elementary schools of the same grade actually shewed differences of from 1·8 to 15·1 per cent. *M*; the *M*-number increasing always with the narrowness of the street, so that the new schools built in *wide streets before the gates* had 1·8 to 6·6 per cent. *M*, while in the heart of the old town, the schools buried in streets of "crushing narrowness" had 7·4 to 15·1 per cent. *M*. This fact deserves the attention of the authorities. It justifies the conclusion that the *darkening* of the schoolrooms, caused by the situation of the building, *must* have decidedly contributed to the production and increase of myopia. Indeed, in many of these rooms it is so dark that in the winter the reading and writing lessons have to be omitted both in the early morning and in the afternoon.

In higher schools I should not draw such a conclusion, because the manifold home employment of the children prevents us from making any such simple experiment as in elementary schools, where but little is given in the way of home lessons.

The removal of schools from narrow streets to open squares and wide roads is urgently required; and it is generally advisable that *for new schools such sites only should be chosen as can never have the needful light taken away by neighbouring buildings.*

Those schools which cannot at once be removed would be greatly improved by making *more windows* and by broadening and lengthening the existing windows. What the builder's art can do in this respect may be seen by the huge shop windows which by means of narrow iron supports have been easily made in some of the oldest houses in the town. Why cannot this be done just as easily in old schools. Where there's a will there's a way. The new Director of the Elizabeth Gymnasium has managed to enlarge the windows in his darkest class rooms at least and to close some class-rooms altogether. One class room (the Septima) of the Elizabeth Gymnasium, situated on the ground floor in the courtyard, was the darkest I ever saw. As early as 1865 its unhealthiness was unanimously acknowledged by all teachers and medical men. This room was turned into a teachers' library, though not till 14 years had passed.

That a good day lighting in schools is of course not the only point to be considered is plain. Just[39] of Zittau, who found 80 per cent. *M* in the 2nd class of a gymnasium, built so recently as 1871 and containing many well lighted rooms, lays the blame on the number of home lessons which are often learned by very poor light. This however should not prevent us from trying to get the best possible light in our class rooms. In respect of this matter, it is an important fact that Florschütz[43] attributes the decrease of *M* in the Coburg schools from 21 to 15 per cent. to the new "School-Palaces" and that Seggel attributes the favourable results in the Bavarian Military School partly to good lighting. In this school he found an increase of only 14 per cent. in *M* from the 13th to the 19th year as compared with 28 per cent. in the gymnasia. Seggel certainly mentions as another cause of the improvement the wise *division of the working hours* in the Military School,

where the hours for study are properly interrupted by recreation and bodily exercises.

5. *Blinds.* Equally injurious with want of light is, of course, direct bright sunshine. In our climate cloudy days are on the whole far more frequent than sunny ones. Sun light can easily be tempered by blinds, which must of course be well arranged and kept in order. The best colour for them is light grey, and the best material linen. The Swedish school at the Vienna Exhibition[62] was fitted up with blinds of fine yellowish aspen laths as narrow as a penholder. These blinds could be drawn up by a cord. They appeared to me too apt to get out of order. An Austrian model school exhibited by Schwab[79] at the same time was fitted up with blinds of coarse unbleached linen; but as the roller was placed at the bottom and the blind drawn *upwards* the whole window was obliged to be darkened if disturbing sunlight came into the room only through the upper part.

In an American school-house[62] in the Vienna Exhibition, I found a very thoughtful and practical arrangement. The rods of the blind were in the middle of the window. By four endless cords the blind could be drawn from the middle of the window up or down, the whole window could be shaded, and by moving the rods up and down you could even regulate the lighting at pleasure. This method of fixing blinds is the care of a special company, the Chicago Curtain Fixture Company. The blinds were of yellow waxed-cloth.

Weber[44] of Darmstadt thinks blinds altogether unpractical because they cannot be used in rapid alternations of sunshine and cloud; he commends as the sole means of regulating the light, and as admirable in another respect, *ground glass, which can be ground on one side only and so superficially as to absorb scarcely any light.*

The Strassburg Report, however, condemns ground glass as dazzling, and pronounces for roller blinds, which no schoolroom is to be without.

6. *The colour of the walls* should be neither dazzling nor dark. A light grey is most to be recommended.

SUPPLEMENT TO THE THIRTEENTH CHAPTER.

(FOR THE ENGLISH EDITION.)

PHOTOMETRY OF DAYLIGHT IN SCHOOLROOMS.

*In the year 1882 the Minister of Public Instruction in France convoked a Committee, which investigated very thoroughly the lighting of schoolrooms. The Committee dwelt especially upon this point, that as the most essential light was that falling directly from the sky upon the scholar's place, every scholar should be in a position to see a piece of the sky, corresponding in size to a window-space of at least 30 centimeters' length, measured from the upper edge of the glass of the upper window. According to my calculation, the angle would then be about 3° at a place 20 feet [6 meters] from the window; and that is, I believe, the greatest width of an ordinary schoolroom at the present time.

Forster† wishes a minimum of 25° for the angle of incidence at the scholar's place and also a minimum of 5° for the "angle of aperture." "Angle of aperture" is the name he gives to the angle subtended at the scholar's place by the edge of the opposite roof and the topmost edge of the window.

These proposals refer only to the angle of elevation and angle of aperture in a *vertical* sense and leave altogether unnoticed the *width in which the light falls.* But it is obvious that this width must also have a very important influence on the amount of daylight.

* Ministerè de l'Instruction Publique, Commission de hygiène scolaire. Paris, Imprimerie Nationale, 1882.

† Vierteljahrschrift f. Offentl. Gesundheitspflege. Bd. XVI. Heft 3, 1884.

The more unsatisfactory were the chemical and electrical apparatuses previously used for measuring light, the greater must have been the pleasure of hygienists at the appearance in 1883 of the new and most ingenious photometer invented by Dr. Leonhard Weber, Professor of Physics at Breslau.* There is no doubt that this instrument is the beginning of a new era in the science of school lighting. (The apparatus may be purchased for 300 Marks [£15] from Schmidt and Haensch, Stallschreiberstrasse 4, Berlin.) By the help of this photometer the amount of light, whether natural or artificial, at any scholar's place may be determined in a minute.

Weber introduced as a standard of measurement the "*meter-candle*," that is, the amount of brightness of a paper held fully exposed to a *normal candle* 1 meter distant. The normal candle is a candle of spermaceti or stearine, of the size which has six to the pound. It is therefore determined in any given case how many normal candles must be burning with direct incidence 1 meter from the place, in order to shed on that place a light equal to that given at the moment in question by the diffused light of day.

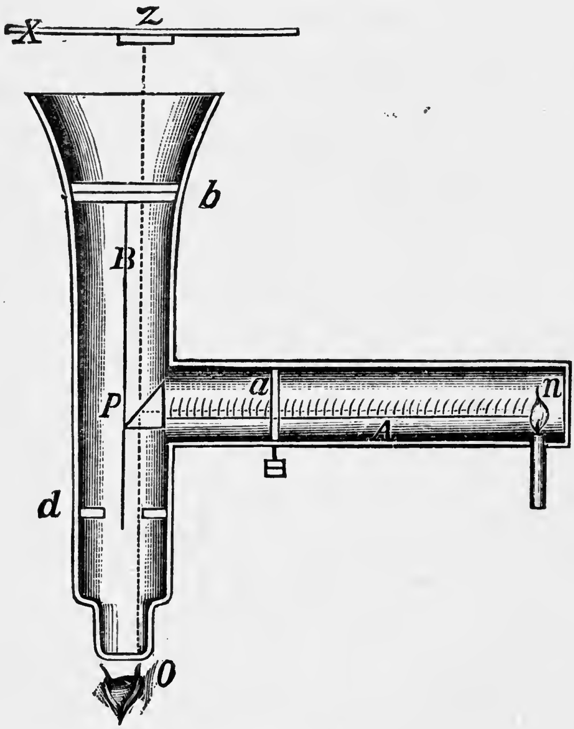
We are therefore no longer restricted to the use of ordinary language in judging of the degree of light found at any place, but are able to apply the touchstone of number.

Weber's apparatus is constructed as follows, in all essential particulars. (Fig. A.) In a fixed, horizontal tube *A* is a normal light *n* (a benzine candle with a fixed height of flame). This candle illuminates a sheet of milk-like glass placed at *a* and movable within the tube in a measurable way. In a second tube *B* which is movable round the axis of *A* is a so-called reflection-prism *P*, that is, a right-angled, three-sided piece of

* Central Zeitung für Optik u. Mechanik, 1883, No. 16 u. 17. See also Wiedemann's Annalen der Physik, 1883. Bd. 20, p. 326. See also Electro-technische Zeitschrift, April, 1884.

glass; there are also at *b* one or more sheets of glass, and at *d* is a diaphragm which intercepts the rays of light at the side of the tube.

Fig. A.



L. Weber's Photometer.

The prism *P* has the property of altering the direction of the rays of light which fall upon it from *n*, in such a way as to cause them to be refracted upwards to *O* (see the dotted line), so that an eye situated at *O* would see the light *n*, not in the tube *A*, but below in the tube *B* and behind *b*.

The light *n* cannot, however, be seen *directly* because it is hidden by the milk-like glass plate *a* in the tube *A*; an eye, therefore, looking through *O* does not see the light, but only sees at *z*, by prismatic reflexion, the glass plate *a*, illuminated by the light.

Now if the tube *B* is directed towards an illuminated surface, such as a sheet of paper *X*, the observer, looking in at *O*, perceives a field of vision cut by the edge of the prism into two halves of equal size and of the same shape, the left half illuminated by the paper *X* and the right half by the light which has passed through *a*. By moving the glass plate *a* in the tube *A*, and by introducing into the tube *B* at *b* plates of milk-like glass (of which the light-obscuring power has been accurately determined beforehand) an equal degree of brightness is obtained in both parts of the field of vision.

There is no difficulty in the case of artificial light; when, for instance, yellow gas light is to be compared with yellow benzine light; but it would be very difficult indeed, almost impossible, to compare, as to brightness of illumination, daylight with yellow benzine light.

Here, again, Professor Weber comes to our aid. He simply places before the eyepiece a piece of *red* glass, which allows only red rays to pass through, so that when the plate *a* has been moved to its proper place (along the millimeter scale) both halves of the field of vision appear not only equally bright, but of the same colour; and it is easy to tell whether two red surfaces are equally bright.

By the help of this invaluable instrument we are now able to say of any given surface, whether vertical, oblique, or horizontal, towards which we can direct the tube *B*, that this surface is as brightly illuminated as if 1, 2, 20, 100, &c. normal candles were shining directly upon it at a distance of 1 meter.

I have very recently, by the direction of the Medical Union, measured the daylight in 70 class-rooms of four High Schools at Breslau, my friend Professor Weber frequently giving me his assistance. I selected two old,

dark Gymnasia in the heart of the town, the Elizabeth (*E*), and the Magdalen (*M*); also the tolerably well-lighted Johannes Gymnasium (*J*), and the new Catholic Municipal School (*C*), which is well lighted in every part. * The measurements were taken from 9 to 11 o'clock. In every class-room I chose the *lightest* place at which a scholar could sit, namely 1—1 1/4 meters (40 to 50 inches) from the window, and also the *darkest* place at which a scholar could sit, namely 5—6 meters (200 to 240 inches) from the window. The measurements were taken twice in every class-room, once on as clear a morning as possible, and once on as dark and cloudy a morning as possible. At times we found it necessary to interrupt the measurements, owing to the alternations of bright clouds and blue sky, which can in a few minutes increase or decrease the degree of brightness by 100 candles or more.

The measurements are of course best performed on days when the sky is uniformly clouded and on days when the sky is perfectly cloudless and blue.

I found the following ranges of variation of the brightness *B*:

At the best-lighted place for a scholar

In *E*	on *bright* days 61 to	450 candles;	on *dark* days 4·7 to	235 candles.
,, *M*	,, ,, 82 ,,	720 ,,	,, ,, 2·6 ,,	182 ,,
,, *J*	,, ,, 189 ,,	1172 ,,	,, ,, 121 ,,	1050 ,,
,, *C*	,, ,, 320 ,,	1410 ,,	,, ,, 79 ,,	555 ,,

At the darkest place for a scholar

In *E*	on *bright* days 1·7 to	32 candles;	on *dark* days <1 to	22 candles.
,, *M*	,, ,, 1·8 ,,	68 ,,	,, ,, <1 ,,	10 ,,
,, *J*	,, ,, 7·9 ,,	133 ,,	,, ,, 3·6 ,,	69 ,,
,, *C*	,, ,, 21·6 ,,	160 ,,	,, ,, 4·6 ,,	38 ,,

The light diminishes with extraordinary rapidity as one goes further from the window. It must not be supposed that light from *overhead* is equally good everywhere.

* Compare my article on Daylight Measurements in Schools. Deutsch. med. Wochenschr. No. 38, 1884. Also Compte rendu du Congrès International Hygiènique à la Haye. 1884.

In a large weaving mill in Schweidnitz I found under a shed roof in different places 190—500 candles. We can form a tolerable idea of the darkness in a school from the candle-number on dull days *for the best places.* In the Elizabeth and Magdalen Gymnasia the best places in 25 classrooms had only a brightness of from 2 to 98 candles; while in the Johannes School there was not one class room in which the best place was below 121 candles even in dull weather; and in the Municipal School there are only two classrooms with places below 100 candles.

I found, I am sorry to say, in the Elizabeth and Magdalen Gymnasia, 13 classrooms where on dull days the brightness (B) is < 1 in the dark places. *Here, then, we have a number of children in 13 classrooms, writing at 11 o'clock in the forenoon of dull days, by less light than that of 1 candle.*

Such figures as these must silence those persons who come forward like Von Hippel* as opponents of state school-doctors and instead of *at once* closing the schools prefer to await improvement of the children's circumstances from the *gradual* spread of hygienic principles.

The light of the *sky* can of course be also measured with Weber's photometer. It is best to measure the light of that piece of sky which directly illuminates the scholar's place in question. This light of the sky *(S)* I found to vary from 305 to 11,430 candles. There were rapid changes from 11,430 to 6714, for instance, when the blue sky was measured into the grey centre of a white cloud near it. It is best, therefore, to choose either uniformly dull days or uniformly bright days.

It is a good thing to reduce the number (B) expressing the brightness of any place to a normal sky of 1000 candles. The brightness thus reduced *(Br)* would be

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* Rectoratesrede Giessen, 1884. "What measures are required owing to the frequent occurrence of short sight in Higher Schools?"

for the best places in the Johannes Gymnasium =76—645 candles and for the worst 2—27; in the Municipal School for the best places, 91—368 and for the worst 4—19.

Very important also is the *reflexion from the opposite houses* (*Bo*). These are frequently brighter than the sky. Opposite the Johannes School is a pale yellow house which, when the sun was shining on it, showed a brightness (*Bo*)=1866 candles, while *S* was only =1441. It is, however, rarely possible to count on this reflected light.

A very simple method of determining *provisionally* the degree of light in any classroom is to note the number of scholars who from their places in the room can see *no sky at all.* Among 68 classrooms I found 28 containing such places. 2461 scholars were questioned; *459 of them could not see the least bit of sky*; 28 per cent. in the Elizabeth, 24 per cent. in the Magdalen and 15 per cent. in the Johannes Gymnasium. In the Municipal School there was hardly 1 per cent. In the 6th class of the Elizabeth Gymnasium so many as 80 per cent. could not see any sky.

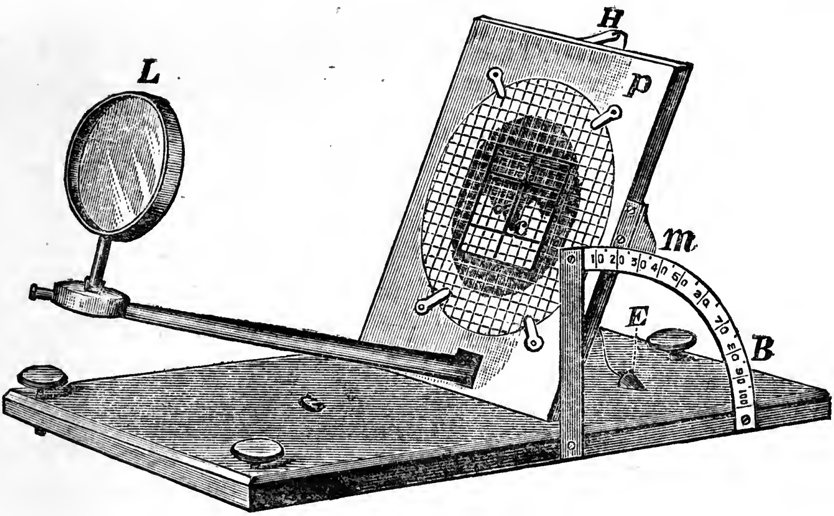
It would be extremely difficult and would take up a great deal of time to measure the piece of sky seen by the scholar, if the measurements had to be taken with the reflecting sextant. I therefore asked Professor L. Weber to construct an instrument which should make it possible to measure quickly the whole piece of sky visible. Weber accordingly invented a most ingenious little instrument, the Stereogoniometer, or Solid Angle Measurer. (Fig. B.)

Imagine from a point *C* on an illuminated table-surface all the bounding lines drawn which, skirting the edges of the window or the roofs (where these are in the

* Described in the Zeitschrift für Instrumenten-kunde, October, 1884. The instrument, price 20 marks, may be obtained from Heidrich, Optician, Breslau (Schweidnitzer Strasse 27) and from Schmidt and Hänsch, Stallschreiber Strasse, Berlin.

way) of the opposite houses, strike directly against the open sky. All these bounding lines enclose a solid angle of which the apex is *C*. The contents of this

FIG. B.



L. Weber's Stereogoniometer.

angle Weber calls the space-angle (ω). If, taking *C* as the centre, a spherical surface of any given radius is described, the space-angle will intercept a certain portion of this spherical surface.

At the illuminated point *C*, then, we place a lens with a focal length of 11·4 centimeters. Behind the lens is a paper ruled in squares, the side of each square measuring 2 millimeters. Upon this paper is of course cast an inverted picture of the piece of sky which can be seen from the place. We outline this picture on the paper. Every square in the figure thus obtained corresponds to the unit taken as a standard in measuring the space-angle, which unit is called a *square degree*. (It may be noticed in passing that, if the whole vault of heaven were so measured, it would contain about 41,253 square degrees.)

With the help of the instrument drawn in Fig. B. we can measure the space-angle ω (expressed in square degrees) and also the angle of elevation α.

The ground plate *G* of the instrument is fixed horizontally on the place to be examined by means of screws and the plummet *E* which hangs down from a suspender *H* attached to the plate *P*. The plate *P*, which moves about a hinge, is placed so that the mark *m* on it points to zero on the graduated arc *B*. The plummet *E* should then be in a line with a point marked on *G*. When the instrument is thus placed, a point of light on a level with it would cast its image through the lens *L* exactly upon a little pin *c* which is fastened on the plate *P*. The side of the plate *P* towards the lens is then covered with a sheet of paper ruled in squares, each side of which measures 2 millimeters. The paper is held in its place partly by the pin *c* and partly by some small brass springs. Now if the focal length of the lens is so arranged that at a distance from the lens of 114·6 millimeters a clear picture, say of the sun's disc when on the horizon, would be formed on the ruled paper, this picture falling on the pin *c*, would be located exactly in a square millimeter; that is, the picture of a disc of four times the size, equal therefore to a square degree, would occupy the space of one of the little squares each side of which measured 2 millimeters.*

The reading off of the mark *m* on the graduated arc would give the angle α, which in this case $= 0^{\circ}$. If the same bright disc stood higher in the sky, we should turn the plate *P* until the picture fell again on *c*, and the reading off of the mark *m* would now give a different value from zero for the angle α. A piece of

* The diameter of the sun's disc occupies, according to Dr. Cohn, about half an ordinary degree, and therefore the sun occupies in the sky about ¼ of a "square degree." [Eng. Ed.].

sky seen from the surface of a desk in a room, and bounded irregularly by the crossbars of a window and by opposite houses casts a correspondingly irregular picture of itself on P.

If, then, we trace with a pencil the outlines of this picture and count up the number of the squares which the picture occupies, including fractional parts of squares, we obtain directly in square degrees the space-angle ω corresponding to the size of the piece of sky seen from the desk.

To facilitate the tracing, the ruled paper is fixed on to a circular disc which can revolve round c. The disc is so placed that the lines coincide as accurately as possible with the contour of the window.

As to the simultaneous determining of α, strictly speaking, a separate adjustment should be made for each particular part of the sky-piece seen from the desk, so as to make the picture fall exactly upon the pin c in each case. But in practice it is quite sufficient to seek for a mean angle of elevation α; and the simplest way of doing this is to turn the plate P until the reflected picture of the sky-piece to be measured is grouped as evenly as possible round c. This can be done with sufficient accuracy by means of the dividing lines on the paper. The reading off of the mark m will then give the mean angle of elevation.

The product $\omega \sin \alpha$ can then be taken as the *reduced* space-angle and gives a number which, neglecting the diffused light of the walls, may stand for the relative measure of the brightness (B) of a place.

With this stereogoniometer I have measured all the places which I had previously tested with the photometer. I give here only the total numbers of classrooms in which the angle ω in *well-lighted* places was $< 300°$ and the number in which it was $> 300°$.

We thus find in the Elizabeth, Magdalen, Johannes and Catholic Municipal Schools—

E	11	classrooms	$< 300°$;	6	classrooms $> 300°$.
M	12	„	„	8	„ „
J	1	„	„	16	„ „
C	0	„	„	13	„ „

But in the *dark* places in 20 classrooms of the Elizabeth and Magdalen Gymnasia ω was $= 0$ (!!). This was the case in only one classroom of the Johannes and in no classroom of the Catholic Municipal School.

In a new village school in Marie-Höffgen, near Breslau, which stands in an open field without any houses opposite and has 4 windows, the darkest place gave $\omega = 116°$, much more, therefore, than the ω of many of the brightest places in the old town schools, which had only $\omega = 40°$ to $70°$.

From the observations I have thus far made, I lay down the following rule:—*The best place must not have a space-angle of less than 500°; and the worst place must not have a space-angle of less than 50°.*

Of course ω is greater in the higher stories and worst on the ground floor. The ground floor should contain nothing but teachers' and school-servants' dwelling rooms, the library, smaller cabinets and the aula which, aula though so seldom used, is always found on the top story with the best light. *The classrooms should be as high up as possible.*

The reflected lights from the opposite houses and roofs often increase the space-angle by 30—90°; on the other hand ω is often diminished even by as much as 24° by the leaves of trees.

In places where ω was 0° the brightness in 20 classrooms varied on dull days from $B < 1$ to $B = 3{\cdot}4$; and on clear days from $B = 1{\cdot}7$ to $B = 8{\cdot}5$. This light, then, is merely reflected from the walls.

Where ω was $< 20^\circ$, B was mostly $= 2—5$ and in some cases so much as 19.

Where ω was	21— 40°, B was	= 3·3 —3·5	candles on dark days.
"	41— 60°, B was	= 12 —19	" "
"	61—100°, B was	= 10 —38	" "

As 10 candles should be the minimum brightness on dull days, it follows that places with a space-angle less than 50° are not to be tolerated.

The cross-work of the windows has an enormous effect. In many classrooms it took away 35 to 50 per cent. from the space-angle. In future we must use slight iron shafts instead of massive wooden cross-work.

The wide wall-spaces between the windows also darken the room exceedingly. For instance, in the well-lighted *quarta (a)* of the Magdalen Gymnasium at 40 inches (1 meter) from the window ω was found to be $= 734^\circ$ and $B = 400$ candles, while at only a yard (0·9 meters) from the window and behind the wall-space between the windows ω was $= 62^\circ$ and $B = 10$ candles. *All architectural adornments should therefore be avoided and the windows should be as wide as possible and close together like the windows of an artist's studio.*

A great effect on the brightness in any room is produced by the tarnishing and the opening of windows and by double windows Of course for every desk the greatest care must be taken that at no time shall a house be built in front of it.

The measurements which show the *loss of light by blinds* were most surprising. The ordinary grey dust-blinds took away 87—89° of the light. White curtains, drawn sideways, only took away 75—82°. In my own children's work-room I use the patent adjustable curtains made by G. Weckmann in Hamburg. They are like Venetian blinds, only that instead of laths made of wood they have little frames covered with grey, transparent stuff; these can be placed vertically, obliquely or

horizontally. When vertical, they took away 91° at a place 80 inches (2 meters) from the window; when oblique 70°, and when horizontal only 57°. They are therefore much to be recommended.

The *marquise* blinds which always cover the topmost part of the window are peculiarly injurious; for it is just this part of the window that gives the best sky-light. All blinds used in school-rooms should be made to *draw sideways.*

The colour of the walls is, of course, of the greatest importance; the smaller ω is the brighter the walls must be. It is a great mistake to have the socle of the walls painted dark. In the Magdalen and Elizabeth Gymnasia there is a dark brown socle 80 to 160 inches (1·5 to 2 meters) high! This accordingly absorbs what little light falls into the room. It is also desirable, for the sake of reflected light, that the dark overcoats, cloaks and hats should not be kept in the schoolroom, but in wardrobes, or hung up in an ante-room which can be locked; not to mention that remaining in a room where 50—70 cloaks, often wet or dusty, are hanging up is not conducive to the health of scholars and teacher.

In rooms facing north there was found, *cæteris paribus*, less light than in rooms facing south. To gain more light in old, dark schoolrooms Forster advises the placing of large prisms before the windows. The prisms, he says, will throw the light further into the room. The practical experiment has not been tried as yet and might fail, owing to the high price of large prisms. At Breslau, however, at von Korn's book-shop there has existed for some time an arrangement of *movable mirrors* such as are used in England. By the aid of these mirrors the light is greatly improved, the shop being situated in the Marstall-gasse, which is only 3 meters wide (10 feet). The glass-maker Krähnert, in Breslau, makes these large adjustable window-mirrors at from 40 to 45 marks

(40 to 45 shillings) per window. My measurement with the photometer showed that a place 3 meters (10 feet) from the window had without the mirror the light of 65 candles and with the mirror the light of 130. Thus the light was doubled. A place 6 meters from the window had its light increased by the mirror from 12 candles to 20 candles. This simple and inexpensive apparatus may therefore be recommended for old dark schools. But the best of all would be to renounce all artificial expedients and to *get rid of the dark schoolrooms as quickly as possible.*

In the darkest place of every classroom those children whose vision was the most acute were made to read No. 1 of Jäger's Types. In the Magdalen Gymnasium there were 9 classrooms in which the type was recognised only up to a distance of 15—25 centimeters. No such places were found in the Johannes or in the Municipal School. In these schools there were 12 classrooms where, even in the darkest place, Jäger's Type No. 1 was read fluently at a distance of from 40—50 centimeters. Those places at which a far-point of 30 centimeters was not attained had on dark days *less light than 10 candles. I therefore fix B=10 as the minimum of brightness.*

These photometric experiments ought to be repeated in every classroom. They could easily be made by the teacher of physical science.

CHAPTER FOURTEENTH.

Artificial Lighting of Schoolrooms.

Artificial light is happily only required for a few lessons in public schools; but it is greatly to be wished that afternoon school were altogether done away with. In elementary schools this might easily be. In our old school buildings the rooms are unfortunately so dark that often on winter mornings gas is burnt for one or two hours. All the schools which I examined[6] had gas. In rooms with from 80 to 100 scholars I generally found two, and never more than four flames. These few flames were so badly arranged that a number of children had the shadow of the body thrown upon the paper. This obliged them to bring the eye much closer to the print or writing and therefore might cause myopia.

The flames were in no single case provided with a shade, so that, although the space above the scholars' heads was brightly lighted, the light was not concentrated upon the desk. Even in the University of Breslau in the year 1867 the lecture rooms had open flames only, and not until I handed in my report upon the eyes of the Breslau students[50] were shades and cylinders everywhere introduced. Baginsky[70] found in the Berlin schools in class rooms for 40 scholars only four flames.

Authors' opinions differ widely as to the number of flames. I at one time proposed to allow one flame to every 16 children. Falk considered this number too liberal. Baginsky and Fankhauser[80] thought it insufficient. The Saxon government ordered one flame to every 7 children. Emmert[27] wishes one flame for every 12 children seated at the new desks, which are further

apart from each other than the old ones. Varrentrapp requires with dual desks one flame for 4 children; Javal a flame for each child. My latest observations lead me to agree with Varrentrapp.

Open flames are wholly to be forbidden. The flickering, the continual jerking movement of the gas stream, causes a rapid alternation of brighter and fainter light and consequently a hurtful intermittent excitation of the retina, soon fatiguing the eyes. No flame should remain without a cylinder. It would be a good thing, indeed, to paralyse the many yellow rays of gas light with blue cylinders, but these again would make the lighting less bright. To concentrate the light upon the desks for work, shades or, better still, porcelain plates or globes are desirable.

Medical Councillor Gross[81] of Ellwangen has invented a shade of his own. He writes, "I placed above a hanging lamp a shallow curved shade made of tin. This must be shaped like a segment of a sphere. Outside this shade is a second circular shade, in shape a truncated cone of which the slope forms with the axis an angle of 30°. The upper edge of this ring-shade hangs by three or four short supports to the outer edge of the upper shade, so that it reflects the light from the side and from above sideways and downwards. The shade should be lacquered a milky white with a dash of blue in it. The dimensions are as follows:

Diameter of upper shade	15·5″
Depth	1·5″
Upper diameter of circular side shade .	15·5″
Lower diameter " " " .	21·5″
Depth of circular side shade . . .	7″
Distance from point of burner (flat wick) to centre of upper shade . . .	5″."

With this method of lighting, Gross, who is himself extremely short-sighted, was able to work many whole nights as easily as by day.

I[6] recommended, instead of fragile globes, tin shades lacquered white inside and having with a height of 6″ an upper opening of 36 sq. inches and a lower opening of 324 sq. inches. Tin reflectors answer very well in our Deaf and Dumb Institution; they are 16 inches [40 cm.] wide below, 4·8 inches [12 cm.] high, and taper upwards to a width of 4 inches [10 cm.]. It is only a short time ago that I was told in a large institution that no new cylinders and globes were procured as the scholars continually broke them.

The Strassburg Report considers that dull glass globes absorb too much light and desires only cylinders and tin reflectors, the flames being arranged in two rows 1 meter (40 inches) above the heads of the scholars.

Where gas cannot be had—which on account of its cleanliness and greater brightness is certainly a good means of school lighting—petroleum should be used. The lighting power of petroleum (according to A. Vogel) is to that of gas as 87 : 100. Oil is not so desirable, because its lighting power is to that of gas only as 63 : 100. On the other hand oil is ~~not~~ explosive.

Erismann[10], who found in Petersburg among 397 boarders of Russian gymnasia 42 per cent. *M* against only 35 per cent. among 918 day scholars, thinks that a cause of the greater percentage is the "too often scanty and badly arranged artificial lighting in the boarding houses." Dor[36] also found in Lyon 33 per cent. among the boarders of the Lyceum and only 18 per cent. among the day scholars.

It is to be hoped that the electric light will soon banish gas from our schools, for the electric light is attended with no danger of fire and does not poison the air nor heat the room.

SUPPLEMENT TO THE FOURTEENTH CHAPTER.

(FOR THE ENGLISH EDITION.)

ARTIFICIAL LIGHTING OF SCHOOLROOMS.

With the aid of Weber's photometer we are now happily in a position to express numerically the illuminating power of lamp-globes, since we can now measure the brightness at different places on a table lighted by a flame of given height without any globe and can measure how much the brightness at these places is changed when various globes are placed over the flame.

This most important question, hitherto wholly unanswered, I have recently undertaken to answer by means of more than 500 measurements.* Only a few chief results can be given here.

For gas circular burners we use tin shades polished inside, tin shades lacquered white inside, milk-glass globes, the so-called Paris shades, mica shades and new-silver reflectors. The public usually call the milk-glass globes *porcelain* globes. This is an error. There are no porcelain globes; they would be too costly, and would absorb too much light. The only globes are of glass, transparent, dulled or milky. The name "Paris shades" is given to those milky globes which have glass plates under them. These plates may be either transparent, dulled or milky.

It is very instructive, with reference to the lighting of schoolrooms, to compare the *polished* with the *lacquered* tin shades. I took two tin shades of exactly the same make, 46 centimeters in diameter below, 8

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* H. Cohn. Untersuchungen über den Beleuchtungswerth der Lampenglocken. Wiesbaden, 1885. Bergmann's Verlag.

centimeters in diameter above and 9 centimeters high. Inside, one of them was lacquered white, the other polished. On placing them over a circular gas-burner of 15 normal candles' power and 1 meter above the table and taking measurements exactly under the burner (0) and at from ½ a meter to 2 meters aside from it, I found the following degrees of light (in meter-candles).

Meters aside from the flame	0	0·5	1	1·5	2
With no shade . . .	1	3	4	2	1
With lacquered shade . .	9	9	6	2	1
With polished shade . .	64	15	6	2	1

(Decimals are omitted for the sake of simplicity.)

These figures shew at once the great gain of light obtained with a polished shade; and, as the lacquered shade is also 6d. more in price, surely no one in future will choose such for schools or work rooms.

The *funnel-shaped milk-glass globes* differ but slightly from each other as to brightness, although they vary somewhat in height. The figures quoted below suppose in all cases a flame ¾ of a meter above the table. I found vertically below the globes about 30 candles' light; at ½ a meter aside 17 to 19; at 1 meter aside 6 to 9; at 1½ meters two candles' light.

The paper shades with *mica* give less light than the milk-glass globes—only 23 candles. The most light is given by the new-silver hemispherical reflector, which lights up a place vertically below the burner with the power of 260 candles! This reflector is to be recommended when the brightest light is wanted on a small space, for instance in shop windows; but it is unfortunately unfit to work by, because of the intolerable heat.

The *lamp-plates* under the Paris shades take away an immense amount of light; the dull plates 33 per cent., the milk-glass plates as much as 46 per cent., if the book is ½ a meter aside from the flame.

Far better are the so-called *eye protectors*, small funnels which fit with their narrower end on to the rim of the burner. There are glazed eye protectors and eye protectors of milk-glass. The former, which only have a thin glaze of milk-glass on the inside, are the best. If they are 1½ millimeters thick, they absorb only 3 to 6 per cent. of the light; but, if they are two millimeters thick, they absorb from 13 to 20 per cent. The milk-glass eye protectors, however, absorb from 18 to 29 per cent. I prefer these thinly glazed protectors to glass cylinders dulled in the lower part, since the glazed protectors do not prevent us from using the mica-cylinders, which are practically unbreakable.

Dull glass *spherical* globes, dull glass *cups* open at the top and milk-glass *cups* open at the top injure the lighting on all parts of the table. More light is obtained when the burner is left altogether uncovered. I found:

At side-distance . . .	0·5	1	1·5	2	2·5 mtrs.
Without globe . . .	11	6	3	2	1
With dull glass spherical globe	9	5	3	2	1
With milk-glass cup . .	5	3	1	1	1
With dull glass cup . .	10	4	2	1	1

With milk-glass cups, therefore, there is a loss of from 40—60 per cent. of light on the table; and yet this kind of lighting is very common in places of public resort (confectioners' restaurants). Another disadvantage is that in the open cup the flame burns without any cylinder, so that the continual flickering makes reading for any length of time impossible.

The *albo-carbon* light, as is well known, is obtained by introducing napthaline vapour into ordinary gas. The flame becomes by this means very white, and the illuminating power of gas can be increased 14-fold. Napthaline costs only one mark per kilogram and improves the light greatly; while, as the burner has

only two little holes of the size of a pin's head, there is a great saving of expensive gas. This method of lighting, then, especially in conjunction with tin shades is in every way to be recommended.

I have also tested photometrically 10 *petroleum* table lamps with different burners. The best light was thrown upon the table by the Excelsior burner, the Sun burner and the circular burner of the Hygienic Normal lamp (Schuster and Bär, Berlin).

I found the following results.

	With no Globe.	With Globe.					
Distance aside (in meters)	0·25	0·25	0·5	0·75	1	1·25	1·5
Excelsior	36	79	27	10	5	2	1
Sun	23	65	25	7	4	2	1
Hygienic lamp	—	56	25	10	4	2	1

With petroleum lamps, tulip-shaped cups and spherical globes are to be avoided for writing; they give far less light than funnel-shaped globes.

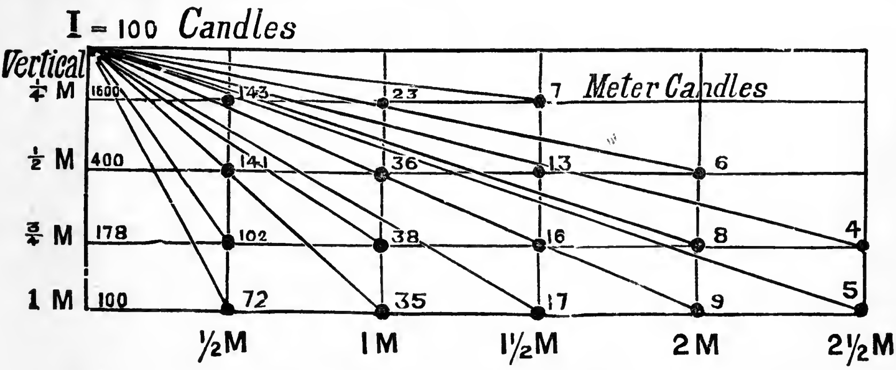
Among *hanging* lamps I recommend the Mitrailleuse hanging lamp made by Wesp of Frankfort-on the-Main. I have used it for years in my children's work-room. The Mitrailleuse has 16 wicks, which certainly must be cut and trimmed very evenly, or the lamp will smoke. It has a burner 10 millimeters in diameter and a little plate like the Sun burner. Above it is a funnel-shaped milk-glass globe measuring in diameter 9 cm. above, 29 cm. below and 14 cm. in height. The flame is 65 millimeters high and, when covered by the cylinder only, gives a light of 22 candles, or more than the best gas-flame. When the lamp, with the globe, hung ½ a meter above the table, the degree of light on the table at ¼ of a meter aside was 91 candles! At ½ meter aside it was 56 candles, and even at 1½ meters it was 4 candles. As it gives at a distance of one meter all round a light

= 14 candles even when pushed up one meter above the table, it deserves to be very highly recommended for schools.*

(I may say in passing, that the new *pianoforte* lamps with reflectors nickeled inside treble the light on the music book.)

The best way to get an idea of the brightness at different distances from an uncovered flame is to use the following scheme invented by the ingenious Professor Weber. (See Fig. C.)

FIG. C.



The letter *I* denotes an intensity of light = 100 candles. The horizontal lines are below the flame at distances of ¼, ½, ¾ and 1 meter; the vertical lines are at distances ½, 1, 1½, 2 and 2½ meters aside from the flame. The number at each dot indicates how many meter-candles would illuminate that place if a light = 100 candles were burning at *I*. For instance, at a work-place one meter below the flame and one meter aside from the flame the brightness would be only 35 meter-candles.

* Later researches of Dr. Cohn "give as the brightest hanging lamp for petroleum the American 'lightning lamp,' (obtainable from Geo. Hermann, of Brieg, in Silesia). This lamp has a three-fold air-supply and is constructed on the principle of fore-warming the air. Hanging one meter above the table and provided with an albatrine shade, it gives, at a point vertically below, 32 MC light, and

at distances aside (in meters)	0·25	0·5	0·75	1·	2·	3·
MC	34	30	28	28	7	2·5

It therefore gives, even at a distance of one meter all round, twice as much light as Wesp's Mitrailleuse."

Now if the figures I have given in tables for the different kinds of lamp-globes with 100 normal candles are placed against the dots in the diagram, the amount of light is obtained for every work-place. It is to be wished—and the wish will doubtless soon be fulfilled—that every lamp-maker and lamp-seller would give such a diagram with every lamp-globe, so that it could be known at once how much light should be expected at any place. School authorities, at least, should henceforth make a point of asking for this table whenever they buy lamps.

The question naturally forces itself upon us: *How many meter-candles, then, are desirable for reading and writing?*

From experiments which I have made with reference to this subject I find that a newspaper, printed in the so-called *bourgeois* type, can be read at a distance of one meter just as easily and quickly when illuminated by light equal to 50 meter-candles as when read by good daylight.

Now a light power = 50 meter-candles can be obtained from any stearine candle if the print is held only 14 centimeters from the flame. But who could work if so close to the flame? We have, however, a number of globes which throw a light = 50 meter-candles, and even more, upon the work-place, thus placing us in the favourable conditions of day light. Lamp-globes, therefore, are important factors.

Now, if we reckon 50 candles as the best substitute for day-light, we are asking nothing unreasonable when we fix as the minimum of hygienic requirements the *fifth part* of the amount of light by which we can read as quickly and as far off as by day. *We ought, therefore, not to approve the use of a flame and lamp-globe at so great a distance that the paper's brightness is less than 10 meter-candles.*

Anyone can convince himself by a simple experiment that the degree of light = 10 meter candles is a very

moderate one. He has only to hold a sheet of paper horizontally 15 centimeters below and 20 centimeters aside from a stearine candle, and a light equal to that of 10 meter-candles will be cast on the point, thus determined, of the paper. A brightness = 1 meter-candle is so little as to make it scarcely possible to decipher a line of newspaper print in a minute, while a healthy eye by 50 candles' brightness, as by day light, can on an average distinctly read 16 lines a minute at a distance of 1 meter.

If, then, we fix 10 candles as our minimum we satisfy ourselves that, even at a side-distance of ¾ of a meter, none of the petroleum lamps in use, except the Mitrailleuse and the Hygienic Normal Lamp, can be approved of and, indeed, that the other petroleum lamps give an available light only within a horizontal distance of ½ a meter. Thus, even with the *best* globes, gas and petroleum flames should not be used for reading and writing at a greater side-distance than ½ a meter [20 inches].*

An *abundant lighting* for work-places in schools is certainly of the highest importance for preventing myopia. Too bright a light can always be moderated, but against too little light there is no protection; and I therefore entirely agree with Javal† when he says: "il n'y a donc jamais trop, il n'y a jamais assez de lumière artificielle."

The *electric* light has been falsely accused of dazzling the eyes. It is of course hurtful to look directly at the glowing charcoal points in an open electric bell-lamp. Such an experiment is very foolhardy. But all lamps should be so placed that the eye of the worker cannot look into them. I have examined‡ the workmen in a sugar refinery where for the last four years the electric light has burnt with great intensity all night long. I found no

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* See Note on p. 167. [Eng. Ed.] † Javal. Revue d' Hygiène, 1879, p. 1045.

‡ H. Cohn. Ueber Künstliche Beleuchtung. (A lecture given at Berlin, 18th March, 1883, at the 10th meeting of the German Union for the Public Promotion of Health.) Deutsche Vichteljahrschrift f. öffentl. Gesundheitspfl. xv. 4.

diseased eyes. I also asked whether the people would prefer to go back to gas. They had no thought of so doing. They were all perfectly satisfied. Poncet de Cluny, (Progrès medical, 1880, p. 627) also says very justly, "There is an entire absence of clinical observations as to the alleged dazzling by electric light; all is limited to a *kind of legend.*"

On the contrary, we must plead all the more earnestly for the introduction of the electric light into schools because its effect both upon acuity of vision and the power of recognising colours is much more favourable than that of gas. I have established this fact by experiments, made for comparison, on 50 eyes of students of Natural Science.*

Again, we must plead for the electric light as less heating to the eye and the head than the light of gas or petroleum. When lighting is too hot, the eye becomes conscious of a feeling of dryness; the moisture afforded by the conjunctiva and covering the front part of the eye evaporates too quickly. This is very troublesome, for of course in this case not the eye only, but the head too, becomes overheated, and headache sets in which finally hinders work from proceeding.

There exist, as is well-known, in the spectrum, in addition to the light-rays and beyond the colour red, the *ultra-red*, or so-called *dark*, *heat-rays.* The heat of these rays can be measured with blackened thermometers and with thermometric columns. There were, hitherto, no measurements for gas, petroleum and electric light. Now I have proved* that, taking an Edison lamp of light-power exactly 20 and a gas lamp with an Argand burner of the same light-power and setting up a blackened thermometer at a distance of 10 centimeters, the temperature rose in 10 minutes about 12·8° with the electric light, and about 23·5° with the gas light, above the

* Archiv. f. Augenheilkunde. VIII., p. 408, 1879.

temperature of the room, which was 14°. This ratio 1 : 2 was also observed by means of a sensitive thermal column.

It follows, then, that *at a distance of 20 centimeters gas-light produces twice as much heat as the electric glow-light.* At ½ a meter's distance from the electric light no heat at all is felt, but at the same distance from the gas light the degree of heat is very considerable.

Of course the heating effect of gas can be diminished by placing the flame high enough above the head; but the brightness diminishes, not as the distance, but as the *square of the distance*, and therefore twice or even four times the amount of light is required if we wish to avoid heat without diminishing brightness. All this is however unnecessary with the electric light, which produces scarcely any heat.

An attempt has recently been made by Schuster and Bär, lamp manufacturers, Prinzessinnen Strasse, Berlin, to reduce the heat thrown out by the petroleum lamps. They place above the flame, and one outside the other, two cylinders between which the hot air passes upward. The result is that the temperature falls at first about 2°; but after awhile the outer cylinder also becomes heated and the gain in coolness is only from ½ to 1°.

That the *violet* colour of the electric light is more injurious to the eye than the yellow colour produced by other lighting is a mere assertion supported by no scientific observation.

The only defect of the electric light, its jerking, has recently been obviated by improvement in the mechanism by which the power is conveyed, so that from an oculist's point of view the introduction of the electric light into schools must needs be advocated without qualification.

CHAPTER FIFTEENTH.

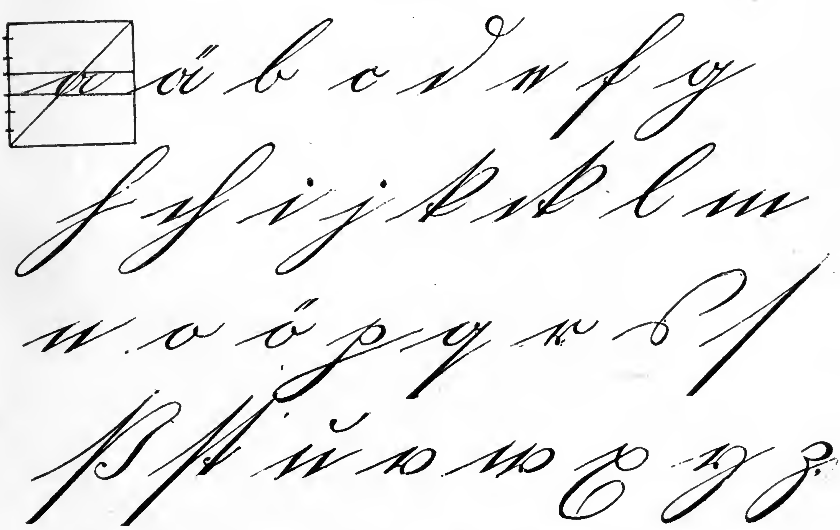
HANDWRITING.

So early a writer as Fahrner[61a] gave forth the weighty sentence: "We let our children grow crooked in order that their handwriting may be nicely slanted." Hermann Meyer[82] of Zürich also pointed out that children seated at bad desks turn their heads to the left (with which movement begins the ruin of their attitude) in order to follow more easily the course of the pen. Ellinger[75] of Stuttgart says with truth that the reason why the children sit so badly is that, with a slanting handwriting, the paper, instead of lying just in front of the writer, is pushed somewhat to the right. The muscles of the eyes are then in a constrained position as they have to look constantly downwards to the right and as the left eye is further from the pen than the right. Now, if the paper is just in front of the child's chest, the two eyes are equidistant from the pen and the child has only to look straight *down.* No group of muscles is wearied by this, and the *base-line* of the eyes, that is, the line joining the pivots of the two eyes, is parallel to the lines of writing and not inclined to them as it is when the paper is aslant. Gross[84] declares that the children's 'vicious' attitude is essentially the consequence (of the unnatural German handwriting and) of the position prescribed for the copy-book. He observed quite correctly that the children sit straight so long as they are making the strokes *straight* with which they begin their writing course, but collapse as soon as they have to make strokes *slanting* from right to left. He therefore considers Greek print to be especially hurtful; and he

was the first to recommend a more upright and rounded handwriting.

The slanting German handwriting is not more than 70 years old; before that time all writing was erect. It was the calligrapher Heinrigs of Crefeld who first introduced in 1809 an inclination of 45° for the German alphabet. In order to establish uniformity among the various styles of handwriting current in Germany, Commissionsrath Henze offered in 1867 a prize for the best national handwriting. No fewer than 754 competitors presented themselves; and by a majority of the 50 judges the prize was awarded to the alphabet of Gosky of Cottbus, in which we already find several curves substituted for angles. But the whole of this prize-alphabet is sloped like its predecessors at an angle of 45°. (See Fig. LII.)

Fig. LII.



There is no lack of official regulations as to the position of the book and the hands in writing; but they often contradict each other. In the Prussian training colleges the rule is that the left arm must be perfectly horizontal; the book must lie parallel to the edge of

the table, the right hand must rest upon the third and fourth fingers only and the wrist must be free. In the Austrian training colleges, on the contrary, the rule is that the upper left corner of the copy-book is to be slanted downward to the left; the *right* fore-arm is to rest on the desk almost entirely; and the left hand is only to touch the desk in order to hold the paper in its place.

I satisfied myself in an elementary School at Aussee in Steiermark in the summer of 1880 that the stooping forward of the head to the left with the book placed horizontally is a necessary consequence of a slanting handwriting. All the children sat perfectly upright when, with the arm stretched out straight and the back against the back-rest, they were ordered to write from dictation and to make the letters vertical. *But the whole class fell forward as if by a stroke of magic when ordered to write slantingly.* In my opinion, therefore, Gross is perfectly justified in advocating a kind of rounded hand which is written with the pen held vertically and which is already appointed to be practised in the upper classes of the Austrian elementary schools.

Dr. Schubert[83] of Nuremberg, in an essay well-worth reading, has treated the question in a theoretical form. He begins his investigation from the fact that the copy-book may be placed before the writer in four positions. (1) Erect central. (2) Erect dexter. (3) Oblique dexter. (4) Oblique central.

1st, *Erect central.* In this position, as Schubert points out, the eyes follow the slanting characters without an undue effort; but *practically* with this position a writing which slants down from the right is impossible. The anatomical relations of the wrist do not allow the pen to be so turned as to form letters slanting down from right to left.

2nd, *Erect dexter.* This position is quite easy so far as the act of writing is concerned. But, if the copy-book

is pushed four inches (10 cm.) to the right of the writer's sagittal plane (which, as is well-known, divides the head vertically into two halves, a right and a left), the *right* eye must in the writing of a line describe an arc $^1/_5$ greater than that described by the left eye. This soon becomes intolerable. Besides this *both* eyes are obliged to maintain a *constant* and maximum turning to the right. Schubert calculates that at the beginning of the line the left eye has to turn to the right about 27° and the right eye 15°, while at the end of the line the left eye has to turn 48° and the right 41°. Now the eyes' maximum inward turns—and therefore those of the left eye—are 42—45°, and the eyes' maximum outward turns—and therefore those of the right eye—are 38—43°. If, therefore, the copy-book is only four inches to the right of the sagittal plane and the body is upright, *maximum* achievements and in part impossible achievements are demanded from the muscles which turn the visual points of the two eyes to the right. The child cannot keep up this muscular strain for any long time.

If an attempt were made to relieve the fatigue by *turning the head*, the head would have to be turned through about 34° to the right. Now the maximum turn of the neck-joint is only 45°, so that the joint would soon be weary and the child would help himself by turning his body to the right. With this turn of the body to the right, however, begins the well-known collapse of attitude which soon ends in the unhealthy approach of the eyes to the writing.

Moreover, as Schubert calculates, with this position of the copy-book the right eye at the beginning of the line is 2·3 centimeters [nearly an inch] nearer to the pen than is the left eye; in the middle of the line 3·6 centimeters [1·4 inches], and at the end of the line 4·2 centimeters [1·68 inches] nearer. This demands unequal

accommodation, a thing frequently avoided by turning first the head and afterwards the spine.

3rd, *Oblique dexter.* In this position the text-lines slant upward from left to right. In addition to the difficulties we have already explained with reference to the erect dexter position, there is now that of following the upward slanting lines by a rotatory movement of the eyes with a horizontal base line. For, as the eyes are turned upward towards the right in different degrees, the vertical meridians must also be inclined towards the right in different degrees. As the retinas, therefore, no longer lie symmetrically, circles of diffusion must arise at the outer edge of the field of vision. Just as it is difficult to read for any long time with head erect from a book in which the lines slant upward, it is difficult to write for any long time with lines slanting in the same way. Compensation is involuntarily sought by turning the head towards the left shoulder until the base line is parallel to the lines of the writing. And this dreaded movement again inaugurates the collapse of bodily attitude.

4th, *Oblique central.* This position of the copy book unites the evils of the first and third positions. Gross recommends it and says that "only a slight inclination of the head is required to obtain a natural position and movement of both eyes." But it is just this inclination of the head that begins the whole bad attitude. For the reasons above given Schubert recommends the erect central position with a writing more like round-hand and having vertical down strokes.

Weber[44] also pronounces against the slanted handwriting because *it requires that the point of the pen shall keep exactly to certain lines of direction and limitation.* The child learning to write must watch the pen's starting point, path and aim and must also guard against any deviation from the line traced for him.

According to Weber, then, the work of the eye in writing is not simply an act of gazing, but of *taking aim.* Now, in taking aim with two eyes, the line joining the two points of sight must be perpendicular to the base-line. But, as the strokes of the letters slant upward from left to right, the sagittal plane of the head must be brought into the same direction, that is, both eyes must aim, with the upstroke, from the ruled line to the pen-point's aim and, with the downstroke, from the pen-point's aim to the ruled line, while that part of the traced line which is covered by the handle of the pen is more easily watched from above. And therefore, according to Weber's observations, children, when writing *carefully*, do not turn the head to the left, but turn the forehead down to the right and look upward at an angle of about 30°, just as if taking aim with a gun in the direction of the pen-stroke.

On the other hand Weber found that with Soennecken's *round-hand pen* the children could perform the writing set them in an erect attitude while perfectly watching the pen-point; that a rounded-off tracing made possible an exact correspondence of ends of the letters with the ruled lines without any injurious approach of the eye to the page; and, lastly, that the rounded style of writing could be written at least as quickly as the Latin.

Prof. Berlin has just confirmed Weber's statements by exact measurements made in the case of 300 children (von Gräfe's Archiv. XXVIII. 2, page 258). He found that with 93 per cent. of the children the base-line was at right angles to the down-strokes. Nevertheless researches about this question are not yet completely ended. Further practical experiments are necessary.

I am indebted to the kindness of Professor Berlin of Stuttgart for some additional and very important remarks on children's handwriting, sent to me during the revision of these pages. Prof. Berlin has together with Dr. Rembold just published by order of the Ministry of

the Interior and the Ministry of Education in Würtemberg a very interesting and original work, "Inquiries into the influence of Writing upon the Eye-sight and the Bodily Attitude of School Children.*

I am sorry that I cannot now enter at length into the details of this valuable work. But the final conclusion must be noticed. Berlin and Rembold have convinced themselves by numerous measurements that it is a mistake to believe that the base-line is always parallel to the ruled line of writing. *Rather, the head is constantly so turned that the base-line becomes perpendicular to the down strokes.* These investigators therefore recommend that the slanting writing be retained, but with the *oblique central* position of the copy-book. The Würtemberg Ministerial Commission agrees accordingly with the following proposals of Berlin and Rembold.

1. The slope of the writing, that is, the angle which the down-stroke makes with a line perpendicular to the copy-book line, should be 30—40°.

2. The copy-book should not be placed to one side, but as nearly as possible *exactly in front* of the centre of the body and so much askew that the line of its lower margin slants upward from left to right at an angle of 30—40°. The proper position is known thus: the direction of the down-strokes is perpendicular to the edge of the desk, and the centre of the copy-book line is as nearly as possible in front of the centre of the body.

3. The upper part of the body is as nearly as possible upright, so as to be supported by the spine. Spinal fatigue is avoided by leaning the lower part of the spine against a back-rest.

4. The horizontal axis of the body, or the line joining the shoulders, is parallel to the edge of the desk; and

* A Report to the Commission appointed to consider this subject, presented by Prof. Berlin and Dr. Rembold of Stuttgart, Sept. 23, 1882, together with the united hygienic proposals of the Commission. Stuttgart, 1883.

it is therefore an unjustifiable practice on the part of some writing-masters to recommend to the pupil a skew posture of the upper body in order to attain an elegant slant handwriting.

5. The body does not press against the edge of the desk, but keeps itself at a distance of about 1·2 inches [3 cm.] from the desk.

6. The head, the cross-axis of which is also parallel with the edge of the desk, is bent slightly towards the table, and not further than is necessary for obtaining a proper inclination of the line of sight to the desk.

7. The elbows are held somewhat lower than the edge of the desk and equally distant sideways from the body. The distance of the elbows from the body should be neither too small nor too great; but the elbow has a certain amount of free space within which, while hanging from the shoulder, it keeps clear of the desk's edge.

8. The fore-arms, but not the elbows, are on the desk and, as the copy book is to be in front of the centre of the body, their position on the desk should be almost symmetrical.

9. This attitude is to be retained throughout the whole act of writing. The upper part of the body and the symmetrically placed upper arms, from the shoulder to the points at which the fore-arms rest upon the desk's edge, should remain as unmoved as possible. Only those parts of the body which are on the desk should perform the writing movements. With reference to these movements the following points should be attended to:—

(a) The movements necessary for forming the letters and single words should be executed by means of the finger-joints and the wrist-joint.

(b) In passing along the line, the right fore-arm, while necessarily moving, should not quit its resting-point

at the desk's edge but, keeping that point as fixed as possible, should revolve about it in such wise as to describe an angle in the plane of the desk. The fore-part of the hand would thus describe a plane arc of which the copy-book line, slanting upward from left to right, would be the chord. In order, therefore, to write the copy book line straight, it is advisable that the distance between the fore-part of the hand and the fore-arm's point of support be slightly shortened, the amount of shortening increasing gradually up to the centre of the line, and gradually decreasing from the centre of the line to the end. This shortening should be effected, not by drawing back the fore-arm, but by slightly bending in the joints of the hand and fingers. To facilitate the observance of this rule it is advised, especially with younger children, to see that the *lines be not too long*.

(c) To begin a fresh line, the fore-arm has to reverse with greater rapidity the slow revolution which it has just made. As the bottom of the page is approached, the distance between the fore-part of the hand and the fore-arm's point of support is more and more shortened. The shortening should be effected, not by drawing back the fore-arm, but by bending in the joints of the hand and fingers and, when this can no longer be done with comfort, by pushing up the paper with the left hand which is resting upon it. This movement of the left hand must also be executed without displacing the left fore-arm from its point of support at the desk's edge, and therefore by means of the wrist-joint or a slight turn of the left arm round its point of support.

10. The head also should, as far as possible, remain in one position during the writing. The slight turning of the head necessary for following the line from left to right is attended with no injurious consequences even with long lines.

11. Steps should be taken for giving managers and teachers sufficient insight into the necessity and importance of these rules, so that they may with the requisite purpose, strictness and energy set about putting them in practice.

12. Reading and writing lessons, playing and working with too minute objects, and near work generally, should be forbidden in all Infant Schools, Kindergartens &c., from which children frequently pass to higher schools with short sight already begun.

13. During the *first* years at school writing lessons should be restricted as much as possible. For this purpose, at the beginning of school life reading only should be practised, and this reading should be from things at a distance (wall-sheets &c.). Then the child should pass to reading from a book; and lastly (not before) he should begin to write the letters. Thus, in the first school-years a writing lesson would not have to be longer than half-an-hour, and the child should be made to leave off every five or ten minutes for a few minutes' rest.

14. The first writing lessons should aim at having the letter-forms made as *large* as possible, and should be less concerned with their evenness and accuracy, even if the standard of good penmanship had to be lowered in consequence.

15. From the net-work of lines on slates and black-boards all *slanting* lines of direction should be removed.

16. Generally, writing when under instruction should be curtailed as much as possible, and in particular there should be as little as possible of *writing in home lessons.* This last should only be allowed when the home provides the necessary space and the necessary light.

17. If it is impossible to do away altogether with written home-work, the teacher, by giving the children

repeated instruction on the point, must do his best to make them observe in their writing at home the proper position and attitude. It is moreover greatly to be desired that the *parents* also should receive instruction on this subject."

Laqueur considers writing generally less injurious than reading. He thinks that the reason for slanting handwriting is the greater ease, from the more extended range, of the curved movements, but that in vertical writing the position of the hand is a constrained one.

In my opinion Kallmann's face-rest will always be of great use in writing, for I have convinced myself that, whatever may be the position of the child's copy-book, the turning of the head required for it does not affect the position as a whole as soon as the head finds at the face-rest its proper permanent support.

Gross, Javal and Weber believe that it is the German alphabet that is especially hurtful to the eyes. Javal even asserts that, if the number of myopes appears to have increasd in Alsace since the annexation (no such statistical result is at all known to me), the German characters are a cause of it. Weber finds that the almost total absence of *hair-strokes* and the easy curves of the letters make the Latin alphabet preferable and that it requires far less visual effort to keep the bends of the Latin letters on the lines, because these bends are not angular as in the German letters, but rounded, so that what has to be achieved is not the coincidence of a point but of a line. Weber says, moreover, that he has satisfied himself experimentally that a child of eight years who has learnt Latin writing for three months and German writing for two years is always somewhat less advanced in the latter.

I can from my own experience affirm that the Latin hand is written more quickly than the German; but I do not think that the German writing has been

proved to be injurious. It is, however, in general desirable that our younger school children should not be tormented with two alphabets at once but, as in almost all other educated states, should be taught only the Latin character.

I entirely agree with School-director Dr. O. Sommer of Brunswick who, in his Easter programme 1883, recommends a steeper handwriting (75° with a somewhat oblique central position of the copy-book) and concludes with the following words his essay, well worthy of attention, "On the Writing Question:" "If it were in our power we would once for all throw overboard the whole so-called German handwriting and confine ourselves to the so-called Latin handwriting, in order to be able to effect at once a great diminution of the reading and writing lessons in the lower classes. When shall we at last be set free from this unhappy gift of the middle ages?"

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CHAPTER SIXTEENTH.

SLATES AND BLACKBOARDS.

"As for slates, they are at any rate a very inexpensive material but, since the strokes made on them are seen as bright grey on a dark grey ground, the contrast of colour is so slight that the use of slates is trying to the eye. It is to be wished that some material better in this respect were discovered."

This wish, expressed by me as long ago as 1867 (cf. "Examination of the eyes of 10,060 School Children"), has only just been fulfilled. A fresh impulse was given to the matter by Prof. Horner.* In 1878 he published, at the request of the educational authorities of Zürich, comparative measurements of acuity of vision as tested with letters of the same size, seen under the same degree of light and written with *slate pencil*, *lead pencil* and *pen* respectively.

It was to be expected that white letters on a dark ground would, owing to *irradiation*, be legible at a greater distance than black letters on a white ground. And this holds good for white *dots* on a black ground. Some years ago I stated that several of my colleagues were able to count black dots on a white ground up to distances of 16, 26 and 50 feet, while they could count white dots of the same size on a black ground up to 22, 34 and 57 feet respectively.

But dots and letters are not the same thing. Horner found that irradiation actually *increased the difficulty* of reading bright letters at a great distance. With E and B for instance, the dark inter-spaces are covered by the bright lines and thus the letters suffer in legibility.

* Deutsche Vierteljahrschr. f. öff. Gesundheitspflege. Bd. X. Heft 4. 1878.

Of course legibility is still further diminished when the letter is grey instead of a good white. The letters B and E were recognised as follows:—

Black on white	up to	496 cm.
White on black	,,	421 ,,
Grey on black	,,	330 ,,

We must also remember the shining reflection of slates which, as Horner aptly says, is of itself enough to banish them from the school, since it is a chief cause of bad attitude.

But, even when this reflection was avoided, Horner found that the same letters were recognised as follows:—

	ON A CLEAR DAY:	ON A DULLER DAY:
With Ink	up to 211 cm.	178 cm.
Lead Pencil	,, 183 ,,	149 ,,
Slate Pencil	,, 159 ,,	132 ,,

The ratio, therefore, of slate pencil writing to lead pencil writing was 7 : 8; and the ratio of lead pencil writing to pen and ink writing was the same: *while the ratio of slate writing to pen and ink writing was 3 : 4.*

Accordingly, an eye which can read ink letters at 30 cm. [12 inches] must be only 22 cm. [about 9 inches] distant in order to read letters of the same size written with a slate pencil.

Now in the first stage of learning every centimeter is of consequence; and therefore Horner was perfectly justified in summing up thus: "The hygiene of the eye demands the banishment of slates and black-boards from our schools and the use of pen and ink in their place. Compliance with this demand will do something to diminish the danger of short sight, a danger which becomes more and more menacing to each successive generation."

What verdict did the Swiss teachers give on this?* Some teachers, who had from the first adopted pen and

* Deutsche Vierteljahrschr. f. öffentl. Gesundheitspflege. Bd. XII. S. 332. 1880.

ink for their beginners, found educational advantages in so doing. They held that there was an end to the clatter of slates, that the children sat up better because they could more easily read what they had written with ink, that there was more order and cleanliness because the children could no longer rub out mistakes; the teacher, too, could with a copy-book better control the scholar's progress. The change certainly increased the work of the teacher, but that was a matter of minor importance, for in any case the transition at a later date from slate to paper was difficult; by constantly using the hard and quickly used up slate pencil, which wrote equally badly however held, the child's hand became stiff, and thus the penholder was twisted in all directions. All this was avoided by using pen and ink *from the first.*

But this opinion was not accepted by the Congress of all the elementary teachers of Zürich after the experiment of using nothing but pen and ink in the local schools had been tried from May 1877 to February 1879. The teachers did not fully agree with Horner, because the scholars were never allowed to write on slates for long together, indeed never for half-an-hour without intermission. They thought that one should pass from the easy to the difficult, and the use of the pen was, unquestionably, attended with great difficulty. Now the children had to be occupied in their very first days at school—an easy matter with a slate but not with a pen. Therefore they thought that the transition to the pen should not take place till the small letters had been mastered. The children sat just as badly over a slate as over a copy-book if the teacher did not give regular attention to their attitude.

Hereupon the *Schuldirection* of Zürich decreed as follows on May 3rd, 1879. "Pen and paper are to be considered as essentially the writing materials,

The use of slates is, however, left to the discretion of the teacher with this condition, that at the beginning of the winter half-year pen and paper shall begin to be *chiefly* used."

Until recently I agreed with Horner, if only for this reason, that as the contrast of ink and paper is stronger than that of slate pencil and slate, the words written must be clearer on paper than on slate.

But, more recently, a great improvement in slates has been discovered, so that the medical man will now be able to meet the teachers' wishes, which no doubt have justice in them.

Herr Emanuel Thieben, a manufacturer of Pilsen, has in fact succeeded in the attempt to replace slates by white tablets of artificial stone. These tablets can be written upon with a special pencil, and the writing can be rubbed out with a sponge without leaving a trace.* A dark-brown pencil was at first used, but a blacker one is to be substituted. A special *ink* may also be used instead of pencil and can easily be effaced and the tablet thoroughly cleansed with *soap*.

I experimented with ten grown-up persons, good observers, and I found that letters of the same size with the same light could be read on the slate at an average distance of 5 meters [16½ feet] and on the white tablets at 6 meters [20 feet].

I have, lately, with Rector Dr. Carstädt, examined 100 scholars of the Sexta and Quinta in the Higher Municipal Evangelical School of Breslau.† A preliminary examination with Snellen's printed test types had resulted, by the way, in the sad discovery that of these 100 boys, from 10 to 12 years old, only 55 were emmetropic.

* Price of tablet 20 to 30 kreuzers [2d. to 3d.]. (Import duty into Germany 3 marks per 100 kilograms.) The inventor will, however, shortly offer them at the same price as slates.

† Centralblatt für Augenheilkunde. 1882. Nov.-Heft.

These 55 emmetropic boys, then, were made to read from a distance a number of letters, very carefully drawn on the slate and the stone tablet after Nos. 6, 5 and 4 of Snellen's types. 16 scholars read them at an equal distance, though always rather more slowly and hesitatingly on the dark slate than on the white tablet. The other 39 read them at a greater distance on the tablet than on the slate. In some cases the distance was considerably greater.

If I call the distance at which the letters were read on the slate 100, the distances for the white tablet are as follows:—

10	children	read	up to	107, 108, 109.
12	,,	,,	,,	114, 116, 120.
8	,,	,,	,,	122, 125, 129, 130.
9	,,	,,	,,	133, 137, 143, 144 and 150.

The average ratio for all the 55 observations was 100 : 116 = about 7 : 8. Writing which can be easily read on the white tablet up to 30 centimeters [12 inches] requires, therefore, when written on a slate, to have the distance reduced to 26 cm. [10·4 inches]. Now as I have urged above in preventing myopia with young beginners, every centimeter is of importance.

There is no doubt that, from an oculist's point of view, Thieben's white tablets deserve the preference over slates, especially as they are wholly free from shine.

Weber differs strongly from Prof. Horner's opinion. He says that the difficulty, exertion and mischief of writing between lines and with lines of direction are just the same whether slate pencil, lead pencil or pen be used. Nevertheless, Weber now recommends, as a substitute for slates, white cardboard tablets made by Bürchl of Worms. One kind of these tablets, written on with charcoal, is in fact excellent, as every mark can be rubbed out *dry* with German tinder. The

other kind,* with which lead pencil is used, I do not recommend, because it must be cleaned with a wet sponge. This softens the tablet and makes the writing-surface blistered and uneven.

The Strassburg Report considers the slate-question generally as of little importance, on the ground that there is no danger of short sight with such young children. I am still inclined, however, to lay great stress upon the point, my experience with the A, B, C regiment having taught me that making these young children work with slates, on which it is difficult to see the marks, is just the thing that very quickly has such an effect on their attitude that, later on, when they write with pen and ink, they have lost the power of sitting straight.

Another point of great importance for the hygiene of the eye is the use of a *good teacher's tablet.* This should be of a good black, but *free from shine.* Wooden blackboards, whether lacquered or polished, are not to be tolerated. Weber and Horner accordingly desire that a huge slate should be let into the wall by the teacher's desk. If the rearmost forms are 9 meters [30 feet] from the slate, the figures written upon it should be, according to Horner,† even with the best light 4 cm. long [1·6 inches] and very thick. With weaker light and difficult mathematical formulæ the writing must, of course, be larger and thicker. According to Horner, fine lightly written figures of the same size and with the same light cease to be seen at all. But, even with the best light and a dull black tablet, soft chalk, and signs written boldly and apart from each other, *the minimum necessary height was found to be three times the height of black printed letters on white paper.*

* Price 6d. [50 Pfennige]

† Schweizer Schularchiv II., Nr. 4.

From a practical point of view, for higher schools, Horner strongly urges, besides the use of good writing materials, the use of *several* properly placed tablets, which can be used in succession and by the side of each other. From many experiments he draws the following conclusions:

(1) Every school should have a copy of Snellen's Test Types, and the teacher should periodically test the acuity of vision of the scholars.

(2) Every (teacher's) tablet should have marked upon it the minimum size for letters and figures.

(3) The teacher should never sacrifice the clearness of his letters or figures to other considerations, such as beauty of form, saving of space, &c.

(4) Except those (teacher's) tablets which are of slate or are faced with slate, all should be condemned, especially the lacquered and polished.

(5) The blackness of the tablet depends on the tablet's cleanliness.

Prof. Köster of Bonn has kindly informed me by letter that from the beginning of his career as a teacher he has in his lecture-room drawn, not with white chalk on black wooden boards, but with soft charcoal on a painter's canvas sized a dull dirty white and stretched on a wedge-frame. "The charcoal can be rubbed off with a dry rag. Apart from cheapness, convenience for drawing &c., the canvas does not reflect or shine. From every place in the lecture-room the drawing, *black on white*, is seen equally well, and much more clearly than white on a black ground."

I have for many years used in my own lecture-room a tablet of dull glass on which I draw with white and coloured chalks. The tablet does not dazzle, and the drawings are seen very clearly. Perhaps Herr Thieben will succeed in making large-sized tablets of his artificial stone.

CHAPTER SEVENTEENTH.

WRITING, DRAWING AND HAND-WORK LESSONS.

Weber recommends lead pencil as less tiring when a great deal of very quick writing has to be done. It is hardly necessary to say that pale ink is hurtful to the eyes. Those inks which do not turn black till afterwards should be wholly banished from schools.

Recently the attention of oculists began to be directed to the method of *teaching drawing*. Dr. Stuhlmann[86] of Hamburg had invented what is known as the *stigmographic* method of drawing, by which it was to be possible to teach drawing to children of from six to nine years. The system depends on a jumble of dots and network, the harm of which, with small embroidery patterns, no one could help seeing *a priori*. The Society of German Drawing Masters has not only protested against the introduction of this method into Prussia, but has appealed to 22 oculists, twenty of whom have agreed that the method is bad for the eyes and that drawing generally at so early an age is unhealthy.

As with network-drawing, so stands the case with the *slant lines* in copy-books. These lines, too, have been forbidden in Saxony. It is simply unintelligible that Adler's copy books should be allowed in the schools of Hamburg, Holstein and Mecklenburg. The demand made on the child's eye by having to track these faint dots, no bigger than a pin-prick, must indeed lead to myopia. (See Fig. LIII.), where however the *paleness* of the dots could not be accurately reproduced.

Now as experience had taught us that excessive writing promotes myopia, I recommended that in higher

schools, from the third class, where excessive writing begins, it should be compulsory to teach Stenography[87].

Fig. LIII.

The stenographic characters are certainly smaller than those of ordinary writing, but they are no smaller than Greek letters. They are very easily learnt, and the saving of time, as I know by the practice of almost thirty years, is so great that no objection ought to weigh against it. How many hours of home-work would the pupils of the first and second classes be spared if they could write down their rough drafts and preparations in shorthand instead of in the ordinary character! And it is in these very classes that short sight increases so alarmingly.

According to Weber a great deal too much is made of penmanship in Germany, while in France, England and America far less time is devoted to teaching it.

Girls' sewing-lessons, also, need medical supervision. So early as 1813 Beer[88] wrote: "I saw little landscapes embroidered on snuff-boxes with the so-called pearl stitch. They were scarcely inferior to an excellent miniature painting and showed an intelligence on the part of the needlewoman which would have done credit to any trained artist. With the deepest pleasure I looked at those pictures till I thought of the eyes of the worker, and the thought turned my joy to bitterness." Words like these might be repeated to-day. Even in Froebel's Kindergartens little children are taught occupations far too trying for their tender eyes

I have classified hand-occupations in four divisions, according as the degree of fineness of the meshes and stitches lets the work be seen with greater or less difficulty, or not at all, *at a distance of one foot.* All those *coarse* kinds of work, in which the meshes and stitches can be clearly distinguished at arm's length by a healthy eye are not injurious. Such are knitting, crocheting with wool, netting, coarse darning, and ordinary making of garments. The second kind of work has to do with meshes and stitches which a healthy eye can only see with a great effort at a distance of one foot and at an angle of 1 minute. To this class belong *fine* darning, appliqué of muslin on net for curtains, embroidery in colours, the old German Holbein embroidery (so called), mignardise crotchet and the favourite filet-guipure. The third class includes fine white needlework, English and French embroidery, button-holing, satin-stitch and marking. This kind of work, by its greater minuteness, leads very frequently to myopia or asthenopia. The fourth class, that of superlatively fine needlework—point lace, petit-points, fine pearl embroidery, and genuine lace work—is absolutely injurious. There is, moreover, a special reason for avoiding satin-stitch in schools, namely, that this work is stretched on a frame, which cannot be brought near the eye like the other kinds of work, but the eye has to be brought near to it.

Weber goes still further than I. He even condemns knitting. "Who, for instance, would be plagued now-a-days with *knitting* a stocking which requires from 35,000 to 60,000 meshes, according to the fineness of the material, if it can be made faultlessly in three hours at the longest?" But Weber goes really too far, when he proposes to give our girls, instead of a stocking, Greek classics or teach them conic sections. He is, however, in complete accord with me in forbidding all

handwork which must be held closer than 14 inches [35 centimeters] to the eye. Of course special tables are needed for feminine hand-work: sewing-tables, long cushions and, in the daytime, light *from above.* Generally, no hand-work lessons should be given by lamp-light.

CHAPTER EIGHTEENTH.

Print and Paper.

As far back as the days of Francis the First, in February, 1746, an imperial patent went forth concerning "The books in the Holy Roman Empire and the Commission by royal grace thereover appointed." *The words of this patent were: "Seeing that we have heard with displeasure that, to the hindrance *reiliterariæ*, many printers and publishers use paper that is much too bad and letters that are hard to read, and that this has already been commanded by Our predecessors to be changed as a most mischievous thing, which command has up to this day been ill obeyed, We therefore graciously decree, *in order to avoid the withdrawal of privilege in respect of any such badly printed book*, that every publisher and printer shall henceforth use *good white paper and readable type*."

Complaints have been made by oculists tens of years past of the ever diminishing type of books and newspapers. Von Arlt[90] in 1865 said very truly, "How much mischief is done to the eyes by the Tauchnitz stereotype editions of the Greek and Latin classics, by the pearl type of our Groschen Libraries of German poets and authors and by the diamond type of pocket dictionaries—in which as many as 50 words beginning with a whole number of identical letters are arranged on one page to the bewilderment of the eye that seeks among them! How much mischief, too, is done by the

* Cf. Emminghaus's Corpus juris Germanici. 2nd ed. Jena, 1814. pp. 565, 567. Cf. also Zöpfl, Deutsche Rechtsgeschichte. 4th edn., 1872, II. p. 411.

pretty little maps, where one would like to have a magnifying glass in order to see the names of the places! The number of persons whose length, endurance and keenness of sight has been ruined in this way is in fact not small. I remember very well that, when I had finished my student years, I was unable to distinguish on the slope of a mountain about an hour distant the same objects which I had seen very clearly when I was in my 13th year."

Javal of Paris was the first to treat scientifically the question of print. This he did in 1878 in his "Essai sur la physiologie de la lecture" (Annales d' oculistique, tome 79-82), a very valuable and thoughtful work. It is only to be regretted that there are no diagrams with this essay.

Javal in his observations chose for unit that size of the national French type which measures about 0·4 millimeters. This unit does not exist in Germany; the 8-point petitschrift approximately corresponds to it.*

SPECIMENS OF TYPES.†

Pearl	n
Nonpareil	n
Brevier	n
Long Primer	n
Pica	n
English	n
Great Primer . . .	n

* Petitschrift is of about the same size as our Brevier. [Eng. Ed.]

† The German original gives specimens of "n" in Perl-Schrift, Nonpareille, Petit, Corpus, Cicero, Mittel and Tertia. The respective n's of these types have approximately the following heights in millimeters: 0·75, 1·0, 1·25, 1·5, 1·75, 2·0 and 2·5. These types are about equivalent to the English types here given. Dr. Cohn gives also paragraph specimens of German type, which are here omitted. In his Latin-printed pairs of parapraphs the interlineages, in millimeters, are 'about' 1 and 1·5, 1·75 and 2, 2 and 2·5, 2·5 and 3 respectively. [Eng. Ed.]

[PARAGRAPH SPECIMENS, SHEWING FOR EACH TYPE A NARROWER AND A WIDER INTERLINEAGE.]

NONPAREIL.

It is well-known that Schilling's design for the national monument on the Niederwald did not always present the appearance now familiar to everyone, which the travelling exhibition with the large plaster model has successfully endeavoured to make as life-like as possible.

It is well-known that Schilling's design for the national monument on the Niederwald did not always present the appearance now familiar to everyone, which the travelling exhibition with the large plaster model has successfully endeavoured to make as life-like as possible.

BREVIER.

It is well-known that Schilling's design for the national monument on the Niederwald did not always present the appearance now familiar to everyone, which the travelling exhibition with the large plaster model has successfully endeavoured to make as life-like as possible.

It is well-known that Schilling's design for the national monument on the Niederwald did not always present the appearance now familiar to everyone, which the travelling exhibition with the large plaster model has successfully endeavoured to make as life-like as possible.

LONG PRIMER.

It is well-known that Schilling's design for the national monument on the Niederwald did not always present the appearance now familiar to everyone, which the travelling exhibition with the large plaster model has successfully endeavoured to make as life-like as possible.

It is well-known that Schilling's design for the national monument on the Niederwald did not always present the appearance now familiar to everyone, which the travelling exhibition with the large plaster model has successfully endeavoured to make as life-like as possible.*

PICA.

It is well-known that Schilling's design for the national monument on the Niederwald did not always present the appearance now familiar to everyone, which the travelling exhibition with the large plaster model has successfully endeavoured to make as life-like as possible.

It is well-known that Schilling's design for the national monument on the Niederwald did not always present the appearance now familiar to everyone, which the travelling exhibition with the large plaster model has successfully endeavoured to make as life-like as possible.

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* "This specimen shews the smallest print and the smallest interlineage that ought to be allowed in school books." Dr. Cohn says of the German specimen to which this English one approximates: "This specimen shews the smallest print [n = about 1·5 mm. high] and the smallest interlineage [about 2·5 mm.] that ought to be allowed in school-books." [Eng. Ed.]

In estimating the effect of print on the eye very various factors have to be considered.

1. *The size of the letters.* As, in looking at print, we do not see the types themselves, which can be measured by points*, but only printed letters, I[87] proposed to measure a short letter, "n" for instance, which is easily done. I found that an Antiqua "n" (see preceding table of types) of which the down stroke is 1 mm. high corresponds to the Nonpareil type: n = 1·25 mm. corresponds to Petit type: n = 1·5 mm. corresponds to Corpus type (the name owes its origin to an edition of the *Corpus juris* which was printed in that type); n = 1·75 mm. corresponds to Cicero type. Corpus type can certainly be read easily at the distance of 1 meter; indeed much smaller print can be *seen* at arm's length. But in reading, and especially in reading quickly, we want, not merely that the letters shall be visible, but that they shall be *easily legible;* that is, that they shall be read fluently, for a good length of time and comfortably, at a distance of 20 inches (½ meter.) And in my opinion, if these conditions are to be fulfilled, the height of 1·5 mm. is the least permissible. *Any type which is smaller than 1·5 mm. is injurious to the eyes.* For this book † I have even chosen Cicero type, so that the n is 1·75 mm. high.

As an angle of sight of five minutes is sufficient for the recognition of a letter, a healthy eye will, according to Weber, be able to read clearly at the distance of 35 cm. [14 inches] the angle of convergence of the eyes being then very moderate (11° 21′)—a letter 0·7

* In England, as the printer informs me, the standard measure of type is pica, the metal-block of which is ⅙ of an inch high. An endeavour is, however, being made to introduce the system of measurement by points. [Eng. Ed.]

† Of course Dr. Cohn is speaking of the German original. The English translation is printed in type of about the same height as the original, but of greater breadth; and the English printer gives more space between letter and letter, word and word, line and line. [Eng. Ed.]

mm. in height. But, even Weber found that in these circumstances the act of reading is, even to the best eyes, very laborious and trying. A wide distinction must be made between clear recognition and rapid reading. Weber accordingly resorted to experiment in order to solve the complicated question. He started from the premiss that, the more favourable to the reader are circumstances as to the size of the letters, the thickness of the lines with which they are formed, the "approach" (see below), the interlineage, the length of the lines of text, the simplicity of meaning &c., so much more rapid must be the act of reading, and so much less must be the eye's expenditure of strength. He accordingly determined the *number of letters* read in one minute* by different persons and under very different circumstances. From these experiments he found that, if the size of the letters was greater than 2 mm., there was no increase of speed; on the contrary the reading was actually retarded. He decides, therefore, for a minimum height of 1·5 mm.

Unhappily only a few even of our medical journals attain this minimum height of 1·5 mm.; in almost all of them we find the ruinous Petit type of height 1·25 mm., and that not only for short notes, but often for page-long records of cases, accounts of experiments, critiques, reports, minutes of medical sessions, &c. The *opthalmic* and *hygienic* papers, too, which ought certainly to take the lead in setting a good example, are not free from Petit type. Even von Graefe and Saemisch's large and widely-read Manual of Opthalmic Science and the Central Opthalmic Journal have whole sections printed in letters little more than 1 mm. high, and

* Weber found from these interesting experiments that the average number of letters read in one minute was as follows: Aloud 1464, silently 1900; that is, per second, 24 letters aloud and 31 silently. It takes, therefore, 0·0316 of a second to recognise a letter and 0·0409 of a second to pronounce it. The difference, 0·0093 of a second, therefore expresses the time required, under the guidance of the impression produced by the printed symbol, for setting free the mechanism of the organs of speech.

therefore almost as small as Nonpareil type. And yet the number of myopes among students, doctors, and scientific investigators is so great. (Compare the measurements of 42 medical journals, 30 natural science journals, and 29 of the most usual school-books in the 5th table appended to my address to the Danzig Assembly of Scientific Investigators, 1880, and also my essay on the eyes of medical students, published in the Vienna Medical Yearbooks of 1881, in which the medical text-books are especially mentioned with respect to their typography.)

If a thing is unimportant, let it not be printed at all; if important, let it be printed in type of the proper size. It is interesting to trace how journals which have existed for nearly a hundred years have changed the size of their type. Lavoisier's Annales de Chimie, for instance, in 1789, and Gilbert's Annals of Physics in 1799, were printed in letters 1·75 mm. high; later the height is only 1·5 mm.

No author should have any book printed in type shorter than 1·5 mm. At any rate no doctor should ever buy such a book. The Strassburg Commission, I am glad to see, considers even this size too small for school-books and prescribes type of 1·75 mm. for the lower classes. I cordially agree.

In Zumpt's Latin Grammar, Krüger's Greek Grammar, Plötz's Manual de la Litérature Française and Vocabulaire an n = 1·25 mm. is very frequent. In Ahn's French Reading Book, in Schuster and Regniers', in Thieme's and in George's Dictionaries, I found letters of 1 mm., and in Lichtenstein and Lange's School Atlas, and also in Sydow's Atlas, letters no larger than 0·5 mm.!

For wall maps Weber advises that the size of the object looked at, the smallest townmarks, figures, letters, signs &c., should be 1 square cm. [about ·16 of a square inch] in a room five meters [about 16½ feet]

long, 2 sq. cm. in a room 10 meters long, and so on in regular proportion.

Javal desires, with perfect justice, that in the school-books of the ABC-scholars *the letters shall not be lessened very rapidly*, before the children have become so familiar with the forms of the letters as to be able to read them *easily*. Unfortunately this is by no means the case in the most highly recommended primers. Javal wishes that it should be determined by experiment how large the type ought to be in the different classes in order that no scholar, however bad the light, may have to get nearer to the book.

We have at length begun in Germany to print *reading-primers* in type sufficiently large. In the year 1881 there appeared in Magdeburg a "First Reading Book for children with weak sight, whose eyes must be spared," by Warmholz and Kurths. The smallest letters are from 4—5 mm. high. Now, as the first steps in learning to read are just the most difficult, and as it is a matter of experience that especially at this stage children pore over the book in order to impress the letter-shapes on their memory, it follows that reading books of this kind ought to be adopted, not only for children with weak sight, but for *all* children. Only, the letters should be still thicker than they are in Warmholz's book, where they are scarcely 1 mm. thick.

2. *The thickness of the letters.* This can only be measured with magnifying glass and vernier. As a rule, the letters are scarcely ¼ mm. thick. Publishers are very fond of thin type because of the saving in paper. The picture of a thick letter upon the retina is of course much broader than that of a thin one. The thick letter is thus read more easily. Fortunately, modern taste in German books is going back to the old Swabian types, which are much thicker than those now in general use. *No print of which the down-stroke is*

thinner than 0·25 mm. should be tolerated in school-books.

3. In Latin (or Antiqua) type *the horizontal strokes at the ends* of the letters are important. Javal directs attention to the fact that the rectangular Latin letters are diminished in their apparent dimensions by the *irradiation* of the white ground, that their angles thus appear rounded off and the letters therefore appear smaller. They look more like  than . To obviate this, the corners must be strengthened to make the letters appear rectangular; for instance, . Ancient specimens of printing shew this thickening of the ends of letters. I do not consider it necessary in German type, because our letters at the lower and upper end have broken outlines or swell into knobs, *e.g.*, .

4. *The shape of the letters.* On this point the advice of the Academy of Sciences in Paris was asked in the days of Louis the Fourteenth. Their report appeared in manuscript in 1704 and reposes to this day in the Paris library, unpublished as yet. Javal, who has gone deeply into this subject, shows that it is very easy to read a line of Latin print if the *lower* half of the line is covered with a sheet of paper, but exceedingly difficult and often impossible if the *upper* half is covered. He pointed out that the reader glances along the line at *a little distance above the centre* of the letters, while only five letters, g, j, p, q and y come below the line, and these five letters, according to the calculations of type-setters, occur on the average only 15 times for every 100 of those which come above or below the line. (In the German type I found the proportion still more favourable. On account of the many capital letters the letters below the line were only 5 in 100.) Javal founds on his observation a proposition which favours the publisher's economy of paper: "The long letters which come below

the line might be altogether suppressed without damage to legibility." He thinks that the lower part of p and q might be done away with, the tails of j and y shortened, and g altered to an ancient and shorter shape. I do not agree with this view. It seems to me, on the contrary, that to break the monotony of short letters by letters reaching above and below the line is very beneficial to the eye, as preventing fatigue. It is by no means desirable that the text-lines should be too close together, especially in school-books.

On the other hand, attention may very well be given to Javal's proposals to make some improvements in the shape of n and u, e and c, so that they may be less easily mistaken the one for the other. There are unfortunately no diagrams, but Javal probably wishes something like the following:  or ,

In the German type there is danger of mistaking n and u for each other, and also c and e. Our n might be made rather broader than u:  and . At the top of our c there could be a stroke such as there is on s:  and . In this way these letters would be more easily read.

5. The *approach* or distance between letters and between words, is also important. Every letter stands out more distinctly by isolation when, as Laboulaye proposed, the white space between two letters is wider than the space between the two ground-strokes of the letter. That is the reason why [in German books] we emphasize by spacing out the type. Javal remarks quite

rightly that this greater approach adds to legibility; a surprising remark from an investigator who attaches so little importance to *leading*, or *interlineage*. Weber found it best to put 60 letters on a line 4 inches long [100 mm]. Laqueur asks for a space of at least 0·5 mm. between two letters. I should fix a minimum of 0·75 mm. [about ·03 of an inch]. In this book the distance is nearly 1 mm.*

6. It is well-known that, in printing, little "leads" are inserted between the text-lines to prevent the long letters above and below the lines from touching each other. This process is called "leading." The wide spaces between the text-lines are advantageous because of their greater brightness and the stronger re-action which this calls forth in the pupil of the eye. Javal, however, looks upon the inserted leads as a pleasant thing, a luxury, not a necessity, and considers that legibility would not be affected by their omission. I found that the compressed print is much more fatiguing, even though it be in a somewhat larger type, than text with spaces between the lines, because too little white is left among the letters and all seems a mass of confusion. A comparison of the compressed and the spaced-out texts in the specimen types given above (p. 197) will satisfy anyone of this. In my opinion the interlineage must be ample. I have tested our school-books and journals in this respect by measuring the distance from the top end of an "n" and the lower end of a short letter above it. Of course the apparent distance between the text-lines is much smaller than we might from this test suppose, because the letters reaching above and below the others diminish the white space of the interlineage distinctly more than do the short letters.

Weber does not profess to determine any absolute minimum for width of interlineage, but only to determine

* The German Edition. See Note on p. 198. [Eng. Ed.]

the ratio of this width to the size of the letters. He makes this ratio 1·5 : 2 for German type and 1·75 : 2 for Antiqua. This seems to me too little, as can be seen by this present work.* The interlineage here is nearly 3 mm., the Antiqua type 1·75 mm. high, and yet the interlineage is nothing very wonderful. A book has *good* interlineage when, if the letters are 1.5 mm. high, the lines are 3 mm. apart. A distance of 2·5 mm. [about 1/10 of an inch] seems to me to be the smallest admissible; and the Strassburg Commission agrees with this requirement.

In former times interlineage was more liberally given. Arago's "Annales de Chimie," at the beginning of this century, had 3·5 mm., but in 1843 only 3·25 mm. Gilbert's "Annals of Physics" shewed 4 mm. so late as 1799, while in the 100th volume, 1832, it had only 3 mm. On the other hand, the interlineage of the Central Journal of Opthalmic Science is 2 mm., that of the German and Berlin Weekly Clinical Journal 1·75 mm., of Schmidt and Virchow's Yearly Report 1·75 mm., of the Chemical Central Journal (in places) only 1·25 mm. I found in primers 2 mm., in Zumpt's, Krüger's and Ahn's grammars 2 mm., in Teubner's Edition of Ancient Classics 2 mm., in dictionaries 1·25 and even 1 mm.

7. The last point to be considered is *the length of the text-lines.* The shorter the line the more easily is it read, because the eyes have the less to be moved. Javal believes the long lines to be the cause why progressive myopia is so frequent in Germany. He considers that, with long lines, short-sighted people must exert their accommodation the more frequently and strongly in the middle of the lines as their eyes are focussed for the ends of lines. It may be so, but it has not yet been proved. Fortunately, the *quarto* form for books is growing more and more infrequent in Germany.

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* The German Edition. See Note on p. 198. [Eng. Ed.]

Already many journals are limited to 80—90 mm. [3·2 to 3·6 inches]. The lines of the Manual of Ophthalmic Science by Graefe and Sämisch are, however, 120 mm. [4·8 inches] long. Even the quarterly Journal of Public Health has lines of 110 mm. [4·4 inches]. Almost all the school-books used in Breslau—except Ahn's Reading Book, Ellendt's Grammar and Paulsieck's German Reading-Book—have lines of less than 100 mm. [4 inches]. It seems to me that 100 mm. [4 inches] is the greatest length admissible, and 90 mm. [3·6 inches] the *best* length for lines of ordinary print where the "n" is 1·5 mm. high. With larger types, such for instance as are used in the present work,* a line of 110 mm. [4·4 inches] is allowable; the length adopted here is 109 mm.

Weber, indeed, concludes from his experiments that up to a length of 150 mm. [6 inches], but not beyond, long lines make it easier to read quickly. He requires a minimum of 100 mm. [4 inches], a maximum of 150 mm. [6 inches] for the normal line. He wishes, therefore, that school-books should be printed where possible in lines of 140 to 150 mm. [5·6 inches to 6 inches]. In this case the whole of the white margin, which he looks upon as superfluous, would have to be omitted, or the book would be too big. This seems to me wrong. The contrast of the dark print with a broad white margin decidedly facilitates reading.

In future I would have all school-authorities, with measuring rule in hand, place upon the *Index librorum prohibitorum* all school-books which do not conform to the following measurements: The height of the smallest "n" must be at least 1·5 mm. [·06 inches], the least width between the lines must be 2·5 mm. [·1 inches], the least thickness of the "n" must be ·25 mm. [·01

* The German Edition. In this English Edition the lines are slightly longer than in the German. [Eng. Ed.]

inches], the shortest distance between the letters ·75 mm. [·03 inches]; the greatest length of text-line 100 mm. [4 inches] and the number of letters on a line must not exceed 60.

Blasius[91] adds: "The 'n' should not be narrower than 1 mm. [·04 inches]; Antiqua type must be spread out as much as possible; the colour of the letters must be a pure uniform black." Blasius, who thoroughly examined, as to all the above-named points, 300 Brunswick and 9 Bavarian school-books, found only 45 or 15 per cent. of the Brunswick books equal to the hygienic requirements; 64 per cent. were unsatisfactory and 21 per cent. positively bad. The Bavarian books were considerably better. Schubert[119], too, among 70 school-books used in Nuremberg, indicates 24 as more or less injurious to the eyes. He wishes that in adjudicating on school-books, besides the points above-mentioned, regard should be had to density *of type*, i.e., the number of letters on a square centimeter.

The type must be deep black, the paper untransparent, and, according to Javal's advice, yellowish in colour. Javal fears fatigue from a sharp contrast between black and white. As the eye is not achromatic, light composed of one colour only would be the surest preventive of coloured circles of dispersion, but, as the light would then be too weak, we ought, according to Javal, to cut off at least the violet end of the spectrum. The colour then remaining corresponds most nearly to unbleached wood paper. Moreover, the Hygienic Congress at Turin in 1880 passed a resolution that in future all school-books should be printed on yellow paper.

Weber, on the other hand, wants not yellow paper, but pale grey. I prefer pure white, for yellow paper causes bluish after-pictures, and black letters can be read further off on a white ground than on a grey. This question requires further experiments.

Blasius thinks *goodness* of paper very important. Paper should be as far as possible of uniform thickness, because a thick sheet is printed much blacker, *cæteris paribus*, than a thin sheet.

The *materials* of which the paper is made must also be carefully taken into account. Formerly papers were made almost entirely of linen rags and cotton rags; additions consisting of wood, straw and clay were very rare. The reverse is now the case. The principal material of paper, especially in school-books, is wood. Professor Lüdicke[91] of Brunswick has found that the showing-through of print in school-books is chiefly owing to a high percentage of wood shavings in the paper. The wood is easily detected with a microscope. Another test is to let fall on the paper a drop of sulphate of aniline. The lighter or darker shade of brown thus brought out shows the greater or less quantity of wood fibre.

On the other hand, accorting to Lüdicke, the thickness or thinness of the paper has nothing to do with the showing-through of the print. Badly printed books, such as Plötz's School Grammar, have paper ·05 mm. thick; Hopf and Paulsieck's German Reading-Book has 0·060 mm., and André's Stories from Universal History 0·080 mm. Well printed books from Vieweg's have paper 0·075 mm. thick.

With regard to the treatment of the paper before, during and after printing, the following matters should be attended to. In order that it may better take the ink the paper should be uniformly damped through before printing: then, to make it as smooth as possible, it is satined, that is, placed between zinc plates and strongly pressed by steel cylinders. In printing, the letters are pressed into the paper so that they stand out in relief on the other side. Print in this state is called "embossed." This effect is neutralised by placing the printed sheets, after they have been thoroughly dried,

between smooth pasteboards and subjecting them to a long continued and very strong pressure. If this is not done the printing appears upon the back of the leaf very indistinct and much obliterated. If the printed sheets are not dried the ink easily comes off from one leaf on to its neighbour lying upon it, and thus the distinctness of the print suffers greatly.

Blasius wishes for all school-books, strong paper of uniform thickness at least equal to ·075 mm., having the least possible admixture of wood matter, satined, free from embossing, carefully dried and of a slightly yellow colour.

CHAPTER NINETEENTH.

SPECTACLES.

Spectacles are good or injurious according to circumstances. Among 10,060 children, I found in Breslau 1004 *M* of whom 107, or 10 per cent., wore concave spectacles. In the village and middle schools I saw no spectacles-wearer; only two girls wore eye-glasses. Half of those *M*'s who were over 17 years of age had begun to wear spectacles; 14 wore lorgnons and 93 spectacles.

Of the scholars with	*M* 1—1·5	spectacles were worn by	2	per cent.
"	" 1·5—2·25	"	8	"
"	" 2·25—3·0	"	20	"
"	" 3·0—4·5	"	46	"
"	" >4·5	"	66	"

Of concave glasses I found 26 neutralizing, 41 weaker (corrective) and 40 stronger (over-corrective). Only 8 of the spectacles had been prescribed by oculists; the remaining 99 had been chosen *at discretion.* Two scholars had even got stronger glasses than had been prescribed for them; 63 used spectacles during the mathematical and geographical lessons only; 47 kept them on the whole day.

There is still a difference of opinion among oculists as to prescribing spectacles for young myopes. Some have a horror of any kind of spectacles so long as the eye is still growing. Others (and, as I think, rightly) prescribe, for medium degrees of myopia, spectacles weaker than are required for neutralization, with the condition that they are not to used for writing, but only for looking at distant things—for the blackboard. Whether, in higher degrees of *M*, spectacles may, or must be, given for

work as well, is a question difficult to decide by a general rule, depending rather in each case on rapidity of growth, tendency to lung disease, muscular circumstances of the eye, &c. At all events it is generally better to prescribe, not spectacles, but lorgnons, which in mathematical lessons, where the eye makes frequent changes from the black-board to the note-book, can drop off, or be taken off, much more easily than spectacles. The removal of spectacles (as I know from my own school-days) is at first omitted as troublesome and, as distance-glasses are thus used for writing, *M* of course is decidedly increased. Unfortunately the old advice, to give no spectacles to short-sighted scholars, but rather make them sit at the front desk, cannot always be followed. Not long ago I proposed that a boy should be placed at the front desk on account of myopia. This was objected to. "The first five desks are already filled with myopes."

A number of short-sighted scholars whom I found in the Breslau schools were, from want of glasses and from their constant bad attitude, courting the increase of their malady. Others had armed themselves with glasses that were positively dangerous. Some had bought eye-glasses from vanity. Others had chosen stronger glasses than they needed, because their companions, who possessed higher degrees of *M*, jeered at them for wearing weak glasses!

Erismann[10] found, among 1245 *M*, 122 (=9 per cent.) wearing glasses. Among the latter he found

100	per cent. with	Atrophy of the Choroid	(against	95	per cent. of all	*M*),
55	"	Insufficiency and Strabismus	("	32	" "	),
42	"	$V < 1$	("	22	" "	).

He also found 12 per cent. neutralising, 69 per cent. weaker and 19 per cent. over-corrective glasses. From these figures Erismann infers "that the use of concave glasses is in itself distinctly injurious for those eyes which are still in

process of changing their refractive relations." This is an erroneous conclusion,[45] quite apart from the fact that, from optical causes alone, the stronger concave glasses diminish *V*. For what is there against assuming that the children were not suffering from atrophy of the choroid, bad *V*, or insufficiency before they got the spectacles? On studying Erismann's tables we find that only one-third of those myopes who had bad *V* used spectacles. Nor has Erismann ascertained for definite degrees of *M* how long glasses had been worn, whether constantly or periodically, nor whether for distance only, or for work as well.

It is one of the most difficult questions to decide whether or not concave glasses are injurious to myopes. The following experiment might perhaps bring us nearer to a solution: Let a certain number of *M*'s, already thoroughly examined with respect to degree of *M*, acuity of vision and muscular and choroidal condition, be observed, who have equally good light, equally good desks, equal length of daily work and equal daily employment; let half of them have corrective glasses and half none; and let them be examined again after months and years. But even this experiment would not be a complete proof, for here, as in other matters, hereditary tendencies and individual differences would constantly exert an influence.

In any case, far more injurious than the use of *proper* spectacles is the forward stooping necessitated by the higher degrees of *M* for those who work *without* glasses. The increased flow of blood to the eye and the scanty flow from it decidedly favours the progress of myopia, quite apart from the mischief done by a stooping posture to the chest organs.

Circumstances were better in Königsberg than in Breslau and Petersburg. In Königsberg Conrad[20] did not find a single instance of too strong spectacles, since

all the glasses in use had been ordered by oculists. School authorities should always forbid the wearing of spectacles by any scholar without medical direction.

As there was no doubt that a number of cases classed as *M* were at first merely cases of *accommodation spasm* in *E* or in weaker *M*, the proposal was made to subject such cases to a temporary treatment with atropine. Indeed excellent results, though to be sure only temporary, have been obtained by Dobrowolsky, Mooren, Schiess, Derby, Schröder and others by the instillation of atropine continued for several weeks. The accommodation-muscle was entirely relaxed by this means. This treatment is disagreeable to the scholar, whom it dazzles; and it leads, occasionally, to slight granulations in the vessel of the conjunctiva (so called Atropin-Conjunctivitis or Atropin-Trachoma) which, however, are very quickly removed. It is in no case really dangerous.

Burchardt[92] applied for permission to try this experiment on a large scale in a school at Berlin but, unfortunately, his wish was refused by the Board of Scientific Examinations. I have myself seen many cases of *M* recede from a higher to a lower degree under a continued treatment with atropine; but for some years past I have made counter experiments which have convinced me that the self-same effect, without any of the unpleasant accompaniments of the atropine cure, may be obtained by giving the eye perfect rest, that is by an entire neglect of all reading and writing for three weeks.

People whose short sight is *progressive* should abstain altogether from reading and writing for some weeks in the year; for instance, in the long vacation.

Javal has recently ordered *convex* glasses for school-children with commencing myopia, in order to enable them to read without exerting their accommodation-muscle, an exertion which, in his opinion, is the chief thing that promotes myopia. He boasts of the result of

his battle with "the old style." It is true, and Donders[16] has already brought the fact prominently forward, that M is rare among watchmakers, because they use the magnifying glass instead of their accommodation. I found in Breslau, among 71 watchmakers[93] from 19 to 71 years of age, only 7 or 9 per cent. M. Of these only four had become short-sighted in the course of their trade. It must not, however, be forgotten that watchmakers only look with one eye, that they sit at the window and in a very good light, and that in Germany they do not begin their work before their 15th year. Among the Swiss watchmakers Emmert[27] found 12 per cent. M, probably because the trade is learnt in Switzerland at an earlier age. Just[39] follows Javal's advice and now orders all commencing myopes for whom the ophthalmoscope gives E or H up to 1·5 D to wear convex glasses when at work. The results, however, have not as yet been made known. It seems to me that the increased forward stooping caused by the use of convex glasses outweighs the benefit derived.

In the case of hyperopes, spectacles for use during work must of course be prescribed.

CHAPTER TWENTIETH.

Over-working the Eyes.

With the subject of "over-pressure," which has been so actively ventilated of late, we are here concerned only so far as regards the question of over-working the *eyes* of school children. It is most certain that over-working the eyes may lead to short sight in spite of the most favourable *locale*, the best desks, books &c. Complaints of over-pressure are nothing new. Seventy years ago, in Vienna, Beer[88] expressed himself as follows: "Anyone who has tried, and tried in vain, as often as I have done, to explain to parents and teachers, in the kindest manner and with the most convincing arguments, how utterly destructive to the eyes of growing young people is the modern system of educational hot-house forcing, must feel it hard indeed to have publicly to repeat his counsels, well-meant and grounded on long experience as they are, and to have to expect the echo of his words to die away, or that they will be heard by only a very few. People hug the ill-understood principle that 'children must be occupied all day long,' and so, all the day long, as fast as one master leaves the room another comes in. Of reading, writing, language-learning, drawing, arithmetic, stitching, singing, piano and guitar-playing there is no end, till the tormented creatures are pale, feeble and drooping and become to such a degree short-sighted and weak-sighted that at last there is nothing for it but calling in doctors to give advice."

With the present number of school-hours, which amounts in the National Schools to 20—22, 28—30, 30—33 a week, and in the Gymnasia mounts up even

to 36 a week, it ought to be a first principle, in order to prevent as far as possible the danger from sitting at writing, that *no two lesson-hours in which writing has to be done should be consecutive.* (Writing and drawing lessons should generally be transferred to the brightest hours of the middle of the day.)

The more we endeavour in our large towns to do away with afternoon school because of the many inconveniencies attending it, the more frequently it happens that lessons go on in the morning for *five* consecutive hours. This is too much for body and mind. Invervals of just five minutes at every two hours have been rightly termed barbarous. There should rather be an interval of *15 minutes* after every hour and of *half-an-hour* after three hours. During these intervals the teacher should not be strict, but he should let the children get up, go out of the room, look out of the window, run about, in short do anything which refreshes the body and so also relaxes the accommodation. For the bodily health and eyesight it would generally be better to return to the old arrangement of three hours' school in the morning and two hours' school in the afternoon.

Zehender[7] goes so far as to express a wish that instruction were given, not in lessons of an hour each, but in lessons of half-an-hour and of a quarter of an hour with long intervals between. He believes that, generally, more could be learnt in a shorter time if the teaching ability of the masters were greater. The Rostock teachers have entered a protest against this "unkind judgment" of their work. A great deal certainly depends on the teacher, and it seems to me especially unjust to appoint as teachers in gymnasia men fresh from the University, who may be first-rate philologists or excellent mathematicians, but have never had the benefit of *pedagogic* instruction in the art of teaching. Pedagogic training for the teachers of

higher schools is most desirable; and with it may be recommended an examination of these teachers in school-hygiene, more especially as some of the older gymnasium-teachers unfortunately meet efforts in aid of school-hygiene in no very friendly spirit.

It is most important that—after five or six hours daily at school, the children should not be over-burdened[95] with many home-lessons. All superfluous copying and all unnecessary reading should be strictly forbidden, simply on account of the eyes. The centre of gravity of learning will always have to be in the school itself. For, unfortunately, home studies are often carried on by a much worse light and with much worse furniture than is the case in school. Just expressly attributes the increase of *M* to home-lessons by bad light and to the constantly increasing demands on home diligence. In my opinion one hour's daily home work for the lower classes, two for the middle and, at the most, three for the first and second classes ought to be sufficient. But what is the state of the case in reality? Alexi* has calculated that in the fifth and sixth classes of the Berlin Gymnasia the number of hours per week required for home-lessons is 10—11, in the fourth and third classes 14½—22, and in the second and first so much as 33 and even more than that. The weekly maximum recommended by Alexi and Chalybäus is: For the sixth and fifth classes 3—9 hours, for the fourth and third 6—12 and for the second and first 12—18 hours.

The fifth conference of Silesian Directors,† on the other hand, appointed the following maximum: For the sixth and fifth classes 10—11½ hours, for the fourth and third 15—19 hours, for the second and first 24 hours. What a pleasing contrast is the recommendation

* Report of the sixth meeting of the German Society for the promotion of Public Health, at Dresden. 1878, p. 59.

† Haase, "Over-pressure of our young people," p. 29.

of the Strassburg Commission of Medical Experts, who fix, as the weekly maximum, for the ninth to the seventh class (children 7 to 9 years old) 6 hours, for the sixth and fifth (children of 10 to 11) 8 hours, for the fourth and third (children of 12 to 14) 12 hours, and for the second and first (15 to 18) 12 to 18 hours.

This ought to be the highest limit for home work; for often enough, private lessons and music lessons add to the burden of home-work.

Zehender goes too far, however, when he lays down the proposition that "no home tasks ought to be given to school children." He looks upon all home tasks as "the resource of an embarrassed teacher to prevent the children when out of school from practising all sorts of mischief and naughtiness." The Rostock teachers do not agree with him. Indeed, even a teacher of the greatest ability could never do without home-lessons; but from a medical point of view it is most strongly advisable that they be as much as possible curtailed.

Herr von Gossler, the Prussian Minister of Education, has recently done a very meritorious thing in recommending to school-authorities the re-introduction of gymnastic games. Hartwich of Düsseldorf and the Central Union founded by him for Physical Culture among the People and in the School have for years been energetic in directing attention to the importance of these games.

Wholly indefensible is the practice of giving, as a punishment, passages to be copied out many times over. The Minister Falk, in an admirable decree of October 14th, 1865, gives an especial warning about this and makes a direct appeal to parents to bring a complaint before the authorities in case of the over-burdening of children with home lessons.

Lastly, the parents, too, or those who have charge of the children, must intelligently guide and control the

children's private reading, banish all ill-printed books and newspapers and prevent the reading for long together even of well-printed books, except with breaks of half-an-hour. They should also see to the reader's posture and never allow any reading, writing, or drawing in twilight or by fire-light or by insufficient artificial light.

The eye, too, must have Sundays and holidays for days of rest.

CHAPTER TWENTY-FIRST

Diseases of the Conjunctiva.

Schools are sometimes visited by a kind of epidemic known as *follicular* catarrh of the conjunctiva, or even by a *granular trachoma*. In the former case the reflecting folds of the swollen conjunctiva (see end of Chap. I.) are found to fit somewhat unevenly to the eyelid in consequence of little blister-like elevations, which disappear again without leaving a scar. In trachoma, or granular inflammation of the eyes, or "Egyptian" inflammation as it is popularly called, there are larger granular formations in the folds of the conjunctiva, which in time produce contraction and scars. As a rule it is not the school that is to blame for this epidemic, but a boarding-house, which, connected with the school, is the focus of the malady.

Such was the case, at least, in Breslau in March, 1874, when inflammation of the conjunctiva broke out in an elementary school specially attended by the children of a neighbouring orphanage. A committee of oculists was appointed, which inspected all the schools on account of the "supposed Egyptian inflammation of the eyes." On this occasion I examined 5000 scholars[96] and found 378 with the mildest form of catarrh, 270 with follicular catarrh, 28 with higher degrees of follicular catarrh and only 22 with the true granular inflammation. Only four per 1000, therefore, had this severe form of the disease.

As the large number of abnormal conjunctiva (698 = 13 per cent.) seemed extraordinary, I made a counter experiment in a village chosen quite at hazard, Langenbielau in Silesia. No one in the village had any suspicion of an epidemic of eye-inflammation and no child complained

of its eyes. I found there, among 1000 village school-children, the above four groups represented by the numbers 54, 68, 1, 2; in all 125 or 12 per cent. of the scholars were diseased. In this village, then, there was just the same state of things as in Breslau. It is probable that these affections of the conjunctiva frequently occur in a latent way in March; whether at other times of the year, I do not know.

That the house, and not the school, is the centre of infection is probable by the breaking out of real epidemics of trachoma in boarding-houses where wash-basins and towels are used in common. Such, for instance, was the case in 1867 in the Deaf and Dumb Institution in Breslau,[97] where, out of 111 children in residence, I found 84 attacked with trachoma, while not a single case had occurred among those children who attended the instruction but lived outside the house. Moreover, the fact that the children who sat next in class to those who were suffering never caught the disease speaks against the conveyance of infection by mere school-attendance. These epidemics are often very obstinate. Our Deaf and Dumb Institution had to battle with one for two years and was compelled temporarily to close the boarding-house.

Becker and Manz[98] are authorities for the frequent and quite harmless occurrence of follicular catarrh in Freiburg, Karlsruhe and Constance* during the summer of 1876. Manz examined at a time of absolute repose the schools of Freiburg in Briesgau and found among 896 boys 1 per cent. hyperæmia, 4 per cent. swelling, and 5 per cent. follicle, in all 10 per cent.; among 807 girls 6 per cent. hyperæmia, 5 per cent. swelling, 11 per cent. follicle, in all 22 per cent In another girls' school he found 11 per cent. follicle and

* In Buenos-Ayres Roberts found among 12,464 eyes of school-children 3,388, or 27 per cent., attacked with *conjunctivitis follicularis.*

in a village school 5 per cent. of the boys with follicle and 21 per cent. of the girls, while I was not able to show any difference in this respect between the two sexes. After several months the state of things in the Freiburg schools was unchanged. Follicular catarrh is not contagious and therefore does not necessitate the closing of the schools. The cure is spontaneous. On the other hand, children with true granular inflammation should, as Manz advises, be excluded from the school.

Except myopia and perhaps affections of the conjunctiva, eye-diseases are not to be connected with school-attendance. Thousands of children have, it is true, been examined for colour-blindness. But this defect is born with the child. It is as little related to the school, and as little curable by training or practice, as is the lack of an eye.

CHAPTER TWENTY-SECOND.

The School-Doctor.

It follows from the preceding investigations that the school may, directly or indirectly, injure the eyes of children and that therefore it is urgently necessary to appoint *special doctors*, whose duty it would be to free the establishments from violations of hygienic law and generally to watch over the health of the scholars.

It is a matter of regret that, until very recently, many school - authorities so little knew and appreciated the importance of examining the scholars' eyes, although they had before them, furnished by numerous writers, statistical proofs, that were simply crushing, of the increase of myopia in the higher classes of schools in all countries.

As lately as 1878 it was disputed by a prominent school-man in the Prussian Chamber of Deputies that Dr. Niemann's investigations in Magdeburg had shown an increase of myopia in the higher classes. It was asserted, rather, that "weakness of sight" had not increased from the lower to the higher classes.

I was able to give proof[34] that in this very town of Magdeburg a most marked progress of myopia has shown itself in both gymnasia (see above, Chapter VIII., Table II.), and that no one has asserted that acuity of vision decreases in the higher classes. Acuity of vision and myopia are two very different things.

How bad, practically, the look-out still is with regard to the observance of hygienic requirements, the following quite outrageous facts, in addition to the instances given in the preceding pages, may show.

In the year 1866 a committee of doctors and teachers[132] pointed out a number of the Breslau schools as too dark. In several of these schools instruction goes on and on *to this day!* In the Magdalen and Elisabeth Gymnasia, where there are so many myopes (see Chapter VIII. Table II.), the gas was burnt in 1866 for several hours daily in winter in open flames without globe or cylinder. Nothwithstanding the committee's advice, in various classrooms of these institutions at the present moment everything remains as it was 17 years ago.*

Weber has had the same experience. "It is ten years ago," he says, "that a committee of doctors, to which my insignificance had the honour of belonging, inspected the sanitary arrangements of all the schools in Darmstadt. It has not come to my knowledge that an impulse to useful action was thus given, and in my recent visit to the schools I did not see the trace of any such impulse. The only result seems to have been 'valuable' material, beside which I hope the words I speak to-day may not be placed as equally valuable."

One director complained to me that he was now compelled for the sake of appearances to teach his own children in his own school; whereas, before he became director, he used on account of the wretched lighting of this school to send them to another.

A fresh instance has just now occurred of the approval of the architectural plans of a very large gymnasium without a medical man's having seen them.

There is not a single classroom in Breslau in which big and little children sit at desks of different sizes.

Even though we are beginning to build the new schools better, yet we continue to force fresh generations into the old bad school premises, which have been rightly called *school-dens*. Among the 60,000 schools of

* The date on Dr. Cohn's title page is 1883. [Eng. Ed.]

Germany how many are there that a doctor has never set foot in? How few teachers can remember ever having seen a doctor in their classroom?

And yet for years past the appointment of special school-doctors has been recommended by various writers—by Schraube,[103] by Falk,[68] by Baginsky,[70] by Virchow,[99] and with peculiar distinctness by Ellinger.[75] When, in Danzig, at the meeting of Natural Scientists, 1880, I ended my address "on handwriting, print and the increase of short-sight" by saying that we want a school-doctor who, invested with *dictatorial power*, shall have to decide upon all the hygienic arrangements of schools, Chief Burgomaster von Winter,[100] a man deserving great credit in respect of the hygiene of Danzig, most keenly opposed the notion of a dictatorial school-doctor, and thought we should rather choose to *wait* and try to spread in wider and wider circles the sense of the benefit and necessity of reform. Let this always be permitted in the case of undertakings that are costly or, as to their final results, not wholly free from uncertainty; but in the war against myopia we must *wait no longer*. For, in consequence of this waiting, short sight for nearly 20 years, in spite of continual speaking and teaching about it, has been promoted in the case of thousands of scholars.

And not only are new scholars continually becoming short-sighted, but in many cases the tendency to myopia is transmitted to their posterity.

As the supreme oversight of all schools belongs to the State, and as the attainments of the aim of their teaching is controlled by state commissions, so also should *medical* commissions see that the claims of hygiene are satisfied in all schools. This duty on the part of the State of hygienic control, is a correlative of the universal school-duty on the part of the subjects. Side by side with the universal *duty* of parents to send their children to school

stands the *right* of the parents to have to send their children to such establishments only as are **healthy.**

The conviction of the necessity for a school-doctor is spreading in the most satisfactory manner in ever widening circles.

In connection with this subject three manifestoes, from societies possessing in the highest degree the knowledge of experts, have made their way to publicity in the last few months.

I. The first manifesto came from the Medical Commission of Strassburg, which consisted of Professors Boeckel, Hoppe-Seyler, Jolly, Kestner, Kussmaul, Laqueur, Neubauer, Ruhlmann and Wasserfuhr, under the presidency of State-Secretary von Hofmann. It is to the lasting credit of Field-Marshal von Manteuffel, Lord-Lieutenant of Alsace-Lorraine, that he, unsolicited, convoked this commission of eminent medical professors to draw-up a report on school hygiene. This valuable report was published in September, 1882.

The 24 concluding recommendations of the Strassburg Commission, a commission which for weeks observed and deliberated in groups, are these:

1. The employment of scholars in school and for school should be, per week, at the most:

Year of Life.	Class.	Sitting Hours.	Singing Hours.	Gymnastic Hours.	Working Hours.	Total.
7, 8	IX, VIII	18	$^2/_2$	$^4/_2$—$^5/_2$	$^6/_2$	24—24$^1/_2$
9	VII	20	$^2/_2$	$^4/_2$—$^5/_2$	5—6	28—29$^1/_2$
10, 11	VI, V	24	2	2—3	8	36—37
12, 13, 14	IV, III	26	2	2	12	42
15—18	II, I	30	2	2	12—18	46—52

2. Between every two lesson-hours, whether in the morning or in the afternoon, there should be a pause of 10 minutes. If more than two lesson-hours are consecutive there should be a pause of 15 minutes between the 2nd and 3rd and of 20 minutes between the 4th and 5th.

3. Let there be one half-holiday afternoon in the course of every week and another at the end of the week.

4. Let no tasks be given between the morning and afternoon of the same day. Sunday is to be entirely free from school-work.

5. Let the Autumn holidays extend from the beginning of August to the middle of September. No tasks to be given during the Whitsuntide and Christmas holidays.

6. The arrangement as to summer holidays is judicious and to be retained.

7. The maximum permissible number of scholars in the several classes is to be regulated according to Pettenkofer's rule. (According to Pettenkofer, every scholar requires in every lesson-hour a supply of 60 cubic meters of air [more than 35 cubic feet], or the air of the schoolroom will contain more than the maximum permissible quantity of carbonic acid, namely 1 per 1000).

8. We recommend that emulation be kept more within bounds and that the one-sided principle be abandoned of attaching so much importance to extempore performances, and that all over-exertion in preparing for the final examination be avoided.

9. Lessons which make great demands on reflection and memory are to be given in the morning.

10. Besides the obligatory gymnastic lessons, swimming practices, out-door games, excursions, and skating are strongly to be recommended. Altogether, eight hours a week should be devoted to bodily exercises.

11. In new buildings for higher schools, the class-rooms, if less than 16ft. 8in. [5 meters] wide, should be lighted by a single row of windows to the left of the scholars. In all wider rooms there should be lighting from both sides. In exceptional cases light may also come from behind the scholars.

12. With one-side lighting care should be taken that the rooms get their light from the east, west, or even north.

13. In school-buildings now existing the use, for teaching, should be avoided of those rooms which get their light only from the south.

14. Where the rooms have not a sufficient amount of light, the defect should as far as possible be supplied by bevelling the window-niches and by opening out fresh windows above in the wall-spaces.

15. Rooms with insufficient light, especially corner rooms in square courtyards, should not be used as class-rooms.

16. Every schoolroom should be provided with roller blinds and with sufficient appliances for artificial lighting.

17. The forms should be so placed that direct light from the sky may get to every scholar. The part of the room thrown into shadow by wide wall-spaces between windows is therefore to be left unused.

18. No highly reflecting surfaces, such as white walls &c., should be allowed near the school-buildings.

19. All faultily constructed desks, without exception, should be done away with as soon as possible and replaced by desks that are constructed rationally. (On Page 35 of the Report the Commission says: "To get rid as quickly as possible of these (old) desks, which their *positive distance* alone is sufficient to condemn, we hold to be the most pressing necessity of school hygiene. *Every half-year's delay produces fresh mischief.* It is by no means a question of a great sacrifice of money. We have made enquiry at a proper place as to the cost, and we find that in Strassburg a large school for 500 scholars can be fitted up with new desks of the best construction at an expense of 7500 marks [£375]. An expenditure, therefore, of at most 80,000 marks [£4000] once for all would suffice to provide all the higher schools of Alsace-Lorraine with rationally constructed desks, and at the same time to put an end to one of the very chief of the mischiefs which lead to short sight.")

20. The print of school-books, charts and atlases should be tested with regard to size of letters, form of type, and distance between letter and letter, word and word and line and line. All books &c. not conforming to the above requirements (entirely in accordance with those which I have proposed above in Chapter XVIII.) are gradually to be banished from the school.

21. The time-tables should be so arranged as systematically to vary the occupations of the scholars and especially to avoid the protraction of reading through several consecutive hours.

22. Short-sighted scholars should be placed in the front rows at the best-lighted places and relieved from all tasks which try the eyes. Stigmographic drawing and fine drawing of maps or geometrical figures should be avoided.

23. It is recommended that, for higher schools also, regulations be issued for guidance as to building-plan, furniture and equipment.

24. Designs for alteration or new-building of a higher school should be examined and reported on, with reference to these regulations by a medical expert officially appointed for the purpose.

II. Shortly after the Strassburg conferences the questions of eye-hygiene in schools were officially considered in the Grand Duchy of Hesse. So early as March, 1881, Geh. Rath Weber had presented, in writing, to the Ministerial Department for the care of Public Health at Darmstadt a valuable report and minute, based on his own abundant experience and observation. This document he now submitted to the deliberations of a committee, consisting of the members of the Medical College and fourteen directors of higher schools. The Committee adopted the following theses, the "Ten Commandments" of Weber (with the exception of the 8th) "which owe their origin to a conscientious consideration of the hygienic as well as the educational needs of the school."

1. With respect to the injurious consequences of bad lighting, the windows, where it is not possible to have skylights, must not be lower than the head of the scholar as he stands upright. Windows in existing schools must be provided with dull glass up to this height and, if on the south or west side of the room, must be filled up to the top with this glass. On the other hand, rooms for drawing and feminine hand-work require in all cases light from above. With respect to further requirements connected with the question of lighting, it is imperatively necessary that the laws relating to school-building be subjected to a revision based on the hygienic principles now established.

2. With respect to the principles, which have been gone into, of good school desks: Lickroth's Normal School-Desks, with leaf 50 cm. [20 inches] wide, should be prescribed; but in rooms for drawing and feminine hand-work furniture from another quarter should be used instead.

3. With respect to the varying heights of scholars in the same class, the distribution of desks is to be guided by measurements of the sizes of the children, taken at the beginning of each half-year.

4. With respect to the necessity for adequate ventilation, the injurious effects of long sitting and of making playtime too short to restore the equilibrium thereby disturbed, each lesson is to be limited to three-quarters of an hour and the remaining quarter of an hour is to be filled up with regulated bodily exercises, gymnastics, drill &c.

5. With respect to the injurious consequences of a bad posture, teachers should be directed to see that a distance of at least 35 centimeters [14 inches] be maintained between *the eye and the work* and that the amount of light requisite for this, which should be set forth in special test-tables, be always provided.

6. With respect to the injurious effect of bad materials, all things at variance with the principles given in the text

(these are almost entirely in accordance with my own proposals in Chapter XVIII.), whether printed matter or net-ruled copy-books, tablets, drawing copies, blank maps or too fine patterns of needlework, are to be banished.

7. With respect to the injurious effects of all near work for children, at least up to the tenth year, and with respect to the necessity for harder mental employment for children of that age, an entire reform of this instruction should be introduced.

8. With respect to the mental and physical mischiefs resulting from calligraphy as now practised, a rounded handwriting is to be substituted for it.

9. With respect to the very slight mental gain to be obtained from it, dictation should in principle be forbidden. It should be allowed only for the briefest notes.

10. *With respect to the necessity for a permanent medical oversight of the schools' hygienic requirements, a* **Member of the Higher Medical Board** *should be invested with plenary administrative and executive powers and, if necessary, a* **special doctor** *should be appointed for this duty.*

We see, then, that our wish for a school-doctor has been expressed by the Strassburg and Darmstadt Commissions also, though unfortunately not with the trenchancy and emphasis which in this matter are so especially needed.

III. Lastly, the Committee of the International Hygienic Congress, January, 1882, placed this very question of a School-Doctor on the order of the day in their programme for the meeting at Geneva, and honoured me with the duty of drawing up a report, with theses, "on the necessity for the appointment of School-Doctors in all countries, and on their duties."

The theses which I brought forward, and which were sent several months before the Congress to members and supporters, were as follows:

1. In the first place a comprehensive State hygienic inspection, as soon as possible, of all public and private school-premises now in use, is necessary.

2. The Government should appoint an imperial or ministerial School-Doctor, who must have a place and voice in the Ministry ; and for every province (Canton, Department) a District School-Doctor, who must have a place and voice in the Governing Council of the district.

3. At the beginning of the hygienic reform the District School-Doctor must review every school in his district, and *close without mercy every school* which is too *dark*, or otherwise injurious to health, unless adequate improvements are immediately carried out.

4. The school can injure health ; therefore *every* school must have a School-Doctor.

5. *Any practical doctor* may be chosen as School-Doctor by the school-authorities.

6. The School-Doctor must have a place and voice in the school's governing body. His hygienic orders must be carried out.

7. If his hygienic rules meet with resistance, the School-Doctor must appeal to the District School-Doctor, who has power to close the school.

8. One School-Doctor should never have the supervision of more than 1000 children.

9. The School-Doctor must give a hygienic report on the site and plan of a new school and watch, with respect to hygiene, over the progress of the building. Attention must be paid to his orders about number, situation and size of windows, arrangements for heating and ventilation, offices and desks.

10. The School-Doctor must measure all the children in every class at the beginning of every half-year and place them at desks suitable to their height.

11. The School-Doctor must determine, every year, the refraction of every scholar's eyes.

12. The School-Doctor has the duty of restricting the number of pupils in rooms which have dark places and of removing school-furniture that forces the child to sit awry and school-books that are badly printed.

13. The School-Doctor has the right to be present at any lesson; he must, at least once a month, visit every schoolroom during lesson-time and take especial notice of the lighting, ventilation, and heating of the rooms and also of the posture of the children.

14. The School-Doctor must be consulted in drawing up the plan of instruction, in order that over-pressure may be avoided.

15. Every case of a scholar with infectious disease must be reported to the School-Doctor. He may not allow the child to return to school until he is *himself* convinced that all danger of infection is over and that the books, copy-books and clothes of the child have been thoroughly disinfected.

16. The School-Doctor must, if the *fourth part* of the scholars are attacked by an epidemic, close the school-department.

17. Every School-Doctor must keep a journal of all hygienic occurrences and especially of changes in the *eyes* of the scholars; and he must forward the journal every year to the Government School-Doctor.

18. The reports of the Government School-Doctors are forwarded to the Ministerial School-Doctor, who publishes yearly a general review of the school-hygiene of the kingdom.

I was unable to be present at the Geneva International Hygienic Congress in September, 1882, and could not therefore present any report on the "School-Doctor question."

However, my 18 propositions were unanimously accepted by the Congress *without discussion;* a sufficient proof that, for experts, they contain nothing but *self-evident*

demands. Napias,[129] Gilbert and Huart merely dwelt on the fact that in several towns of France and Belgium *school-doctors were already appointed.* In the department of the Seine there are 114 school-doctors employed, in Lyon 8; and in Havre, Lille and Brussels the schools are not without medical control.*

* In Frankfort-on-the-Main, too, since 1st April, 1883, a Town-Doctor, whose duty it is to inspect the schools, has been in office.

CONCLUSION.

The time, it is to be hoped, is not far distant when the Strassburg, Geneva and Darmstadt propositions will be posted up in every schoolroom to serve as a daily memento to teachers and school-boards.

Professor Manz[131] very aptly says: "All must help —boards, parents and teachers—to remove, or at least to diminish, the dangers, involved in modern intellectual culture, to physical well-being. One-sided demands upon the eyes must be withdrawn; there must be no more reading, and especially no more writing, than a normal eye can bear without injury; there will always be marauders enough. The conviction that there is much to amend in our school-hygiene is now pretty universal. Much has already been amended; but in many things we are at the beginning, and in most we are still far from the goal; and therefore the school-question may not yet by any means be dismissed from the order of the day."

It must very thankfully be acknowledged that the Government in Breslau, in a decree of the 11th of December, 1882, has directed the attention of the school-authorities to the report of the Strassburg Commission and has required them "to claim *a report by medical experts* not only in the case of all new schools, but also in respect of existing circumstances wherever they appear to be injurious to health. We shall," expressly continues the decree, "direct the attention of District Physicians to the fact that it is a part of their professional duty to observe and advise on these matters wherever an opportunity presents itself, and we have no

doubt that, in any important cases that occur, they will gladly comply with the proposals which have been made to them. But, on the other hand, it is advisable, both in itself and on account of expense, that where the District Physician does not live on the spot, the local practitioners should in the first instance be interested and consulted in this important matter, who, out of public spirit, will gladly respond to the call. . . . . Finally, we herewith decree *that plans for new school-buildings, with the report of the District Physician, shall be henceforth submitted to us for our approval.*"

Whoever has the welfare of our school-children really at heart will certainly desire a *permanent medical control* over all schools. All government decrees and enactments, however well meant they may be, fail of attaining the object striven for if *hygienic* supervision, as well as educational, is not employed.

May the Ministers of Education in all countries, and especially the German Imperial Health Office, call at last into life the urgently needed institution of *School-Doctors*, in order that the school may no longer incur the reproach of promoting the myopia of children. Let the saying of Donders never be forgotten: "Every case of progressive myopia is ominous of evil for the future."

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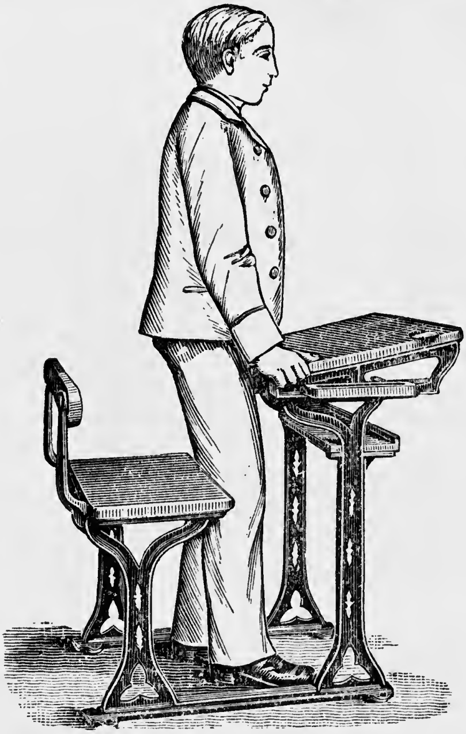
THE HYGIENIC DESK (Patent).



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In an article "On Means for the Prevention of Myopia," *(Ophthalmic Review, June, 1886,)*

Mr. PRIESTLEY SMITH says:—"*To prevent myopia we must prevent young people from using their eyes too closely and too long on near objects.*

"This principle was established long since by the labours of Donders, Arlt, and others, and has been practically developed by Cohn and other reformers of School Hygiene.

A New School Desk.

"Much ingenuity has been devoted to the construction of school desks and seats, and very many different models, each claiming some advantages, have been publicly exhibited during the last few years. At the request of the Midland Educational Company, I have lately designed a school desk which embodies the recognised essentials in as simple and inexpensive a manner as seems to me to be possible. These recognised essentials are as follow:—

"1.—The seat must be of such height as will allow the scholar's feet to rest flat upon the floor or footboard, and broad enough to support the greater part of the thigh.

"2.—The seat must have a back placed at such height as to fit the hollow of the back below the shoulder blades, and support the body in a vertical position.

"3.—The near edge of the desk must be just so high above the seat that when the scholar sits square and upright with elbows to the sides, the hand and forearm may rest upon the desk without pushing up the shoulder.

"4.—As used in writing, the desk must have a slope of 10° to 15° (about 1 in 5); as used in reading, it must support the book at an angle of about 45°, and at a distance of at least 12in. from the eyes—16in. is better (30—40cm.).

"5.—As used in writing, the edge of the desk must overhang the edge of the seat by an inch or two, in order that the scholar shall not need to stoop forwards, and that the support to the back may be maintained.

"6.—Either the desk or the seat, or some part thereof, must be movable at pleasure, so that although the desk usually overhangs the seat, the scholar may be able at any time to stand upright in his place.

"7.—The desks and seats must be of various sizes, in order that the foregoing conditions may hold good for scholars of various ages.

"In a recent paper describing a systematically graduated series of desks ('Progressieve Schoolbanken,' J. van Druten, Utrecht), Professor Snellen gives a table of proportionate dimensions. * * * * *

"Adopting with little alteration the proportions given by Snellen for the various parts of his desk, I have, for the sake of convenience and economy, slightly altered the progression, and reduced the number of sizes to four. Instead of advancing by increments of one-tenth, which is doubtless the right method from the theoretical point of view, I divide the scholars according to their heights into four classes advancing in each case by six inches: thus 3ft. 6in. to 4ft., 4ft. to 4ft. 6in., 4ft. 6in. to 5ft., and 5ft. to 5ft. 6in. The dimensions of the desks are suited to these four heights. The following table gives the dimensions of my desk—the "hygienic desk," Nos. 1, 2, 3, and 4.

"HYGIENIC DESK."

Height of scholars	No. 1. 3ft. 6in.—4ft. 107-122cm.	No. 2. 4ft.—4ft. 6in. 122-137 cm.	No. 3. 4ft. 6in.—5ft. 137-152cm.	No. 4. 5ft.—5ft. 6in. 152-168cm.
a. Height of seat from floor ...	13ins. 33cm.	14½ 37	16 41	18 46
b. Breadth of seat...	10 25·5	11 28	12 30·5	13 33
c. Height from seat to edge of desk Height from seat to top of back	8 20	8¾ 22	9½ 24	10½ 26·5
d. "Overhang" of desk... ...	1 2·5	1 2·5	1½ 4	1½ 4
e. Play of desk	4½ 11·5	4½ 11·5	6 15	6 15
f. Breadth of desk (front and back)	15 38	15 38	17 43	17 43

Slope of desk 1 in 5.

"Its general construction is shown in the foregoing figures. The standards and the cross-pieces which unite them are of cast iron. The back, the seat, the top of the desk, and the shelf beneath it, are of wood. The only points which require description are the book-rest, and the arrangement by which the desk is made moveable at pleasure.

"The flap which supports the book does not extend the whole width of the desk, but occupies the middle portion only, leaving room for an ink pot to be let into the wood at the side of it. The flap when in use is supported by a small stop which hangs from its further edge, and which, though quite firm, can be pressed back by a touch of the finger when the book rest is no longer wanted. The flap is pivotted in such a way that its near edge sinks below the surface of the desk when the flap is raised, and thus creates a groove for the book to rest in (see Fig. 2).

"The wooden top of the desk is screwed to two sloping cast-iron brackets which pass from back to front, one at each side of the desk. Each of these brackets carries beneath its lower or horizontal border a round iron rod, the two ends of which are fixed to the bracket. The rods slide freely through holes or eyes on the upper surface of the standards. By this means the desk is able to slide upon the standands in a direction towards and from the scholar. When the desk is pulled forward a notch in the near end of each rod engages with the eye in which the rod slides, so that the desk is secured in this position, and is not liable to slide away from the scholar if he leans against it. By lifting the front edge of the desk the notches are disengaged and the desk is easily pushed back, so that the scholar can stand up in his place. This is a mechanism which does not get out of order, and which cannot injure those who use it, or be injured by them. The whole desk can, I believe, be made at a cost not much greater than that of many of the old-fashioned un-hygienic patterns now in use."

Mr. T. G. ROOPER (H.M. Inspector of Schools) says:—

1. THE DESK AND BENCH.

"1.—The height of the desk above the bench should be such that when the child is sitting down he can place both his forearms comfortably on the desk, without raising or depressing his shoulders.

"2.—The height of the desk above the floor or surface on which the foot rests should correspond with the length of the child's leg from knee to heel. When the child is sitting down, his legs should not dangle in the air, nor should his knees be elevated above the bench.

"3.—The bench should be wide enough to give support not only to the seat, but also to the upper part of the thigh. It should be at least 10 inches (but better 12 inches) wide. To prevent slipping forward, the bench should be hollowed out towards the back to the depth of an inch.

"4.—Every bench should provide a support for the back of the sitter. This may consist of a board fixed at the back of the bench, at right angles to the seat. The board should be hollowed out in such a way that the upper part of it may fit the concavity of the back. The exact height af the back would vary with the size of the child, but it will be from 6 to 7 inches.

"5.—The desk must overhang the bench during the writing lesson, in order that the child may be able to sit upright, and at the same time support his back. This posture is only possible when the desk overhangs the bench from 1½ to 2 inches.

"6.—The desk should not be level for the writing lesson, but slightly sloping. The slope should not exceed an angle of 20 degrees. The difference between the upper and lower edge of the desk, therefore, should be about three inches vertically.

"7.—As the desk, which is most suitable for writing, is inconvenient for other purposes, the easiest plan of adapting it to all uses is to make the upper part of it moveable.

"8.—Desks of appropriate sizes should be provided for each class.

2. THE POSTURE IN WRITING.

"1.—The writer should sit upright and should lean his back against the support provided for the purpose.

"2.—The shoulders should be kept parallel with the edge of the desk. The writer must not be allowed to screw the body round or to rest the chest against the desk. There should be a space of an inch or a little more between the desk and the body.

"3.—The weight of the body should be disposed evenly on both bones of the seat.

"4.—The head should not droop forward, much less lean on the arm. It may be slightly bowed forward and move a little from side to side as the eye follows the writing.

"5.—The forearms, and not the elbows, should rest on the desk. The pen should be passed across the paper by a movement of the hand and not of the arm.

"6.—The point of the pen should be at least ten inches (better 12) from the eye.

"7.—To make compliance with the above directions possible, the paper or copy book must lie opposite to the middle of the body.

"8.—The paper must not lie square on the desk before the writer, but it must be tilted or askew.

"The lower edge of the paper and the lower edge of the desk should form an angle of from 30—40 degrees.

"The paper is rightly placed when the downstrokes are being made at right angles to the edge of the desk.

"The common attitude for writing often ordered by teachers with the words, 'Half turn right, left arm over slates,' is liable to cause injury both to the spine and to the eyesight."

The MANUFACTURERS of the HYGIENIC DESK claim for it a combination of the scientific principles mentioned in the foregoing extracts, and are confident that it is the best Desk for the PREVENTION OF PHYSICAL DEFORMITY AND SHORTSIGHT *in the necessary close application of School Work.*